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Fern Ridge Clean Lakes Study

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Inflows to Fern Ridge, Oregon bring suspended solids and a great deal of livestock waste. As a result the reservoir has high turbidity (low transparency) and high coliform bacteria counts. Recommendations are: improve swimming beaches by replacing clay bottom with sand; remove debris; correct animal wastes problem; and improve clarity. This report was prepared in partial fulfillment of an EPA Clean Lakes Program grant.

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FERN RIDGE CLEAN LAKES STUDY

FINAL REPORT

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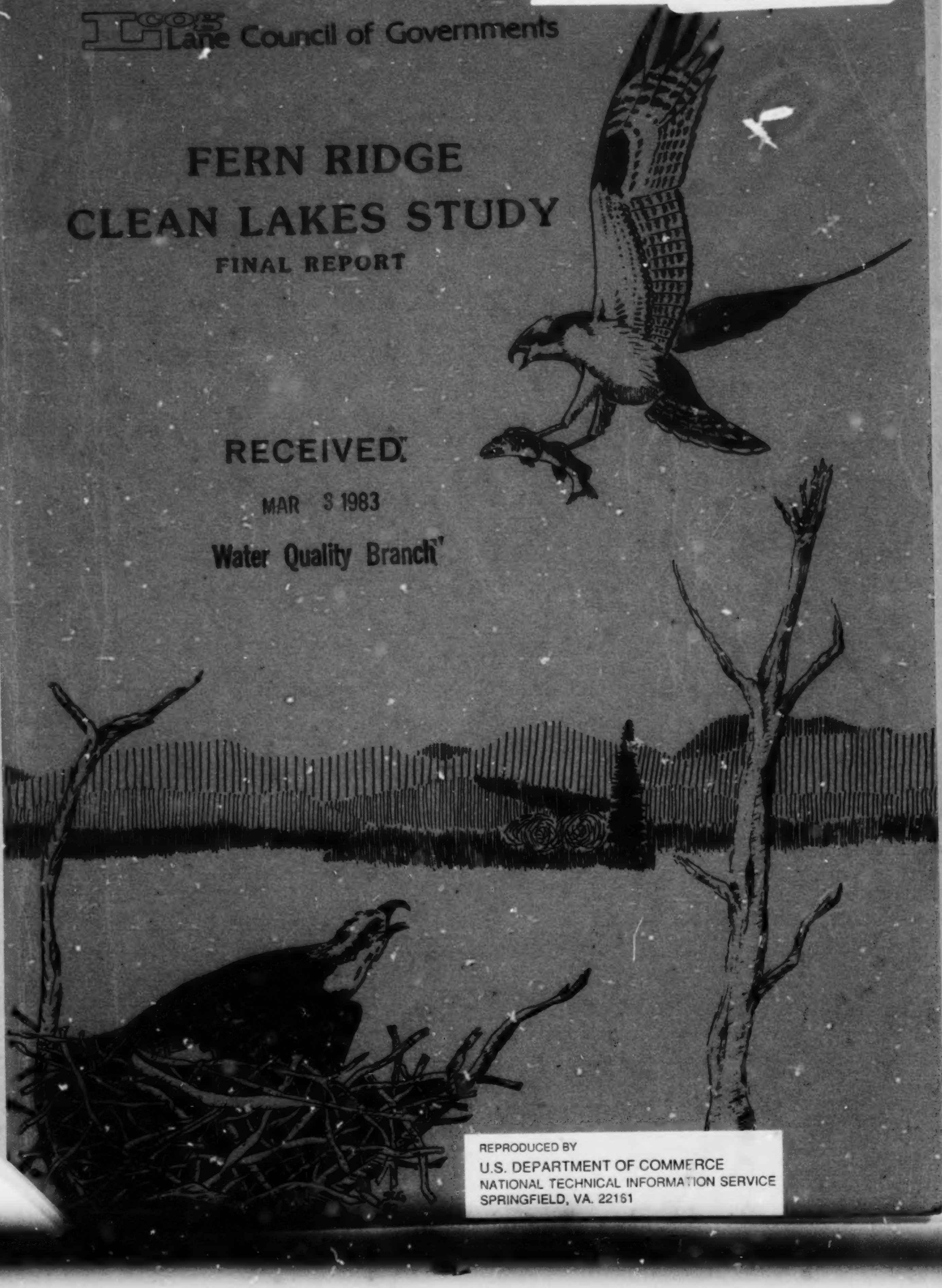

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FERN RIDGE CLEAN LAKES STUDY

FINAL REPORT

Lane Council of Governments
125 East 8th Avenue
Eugene, OR 97401

January, 1983

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FERN RIDGE CLEAN LAKES STUDY

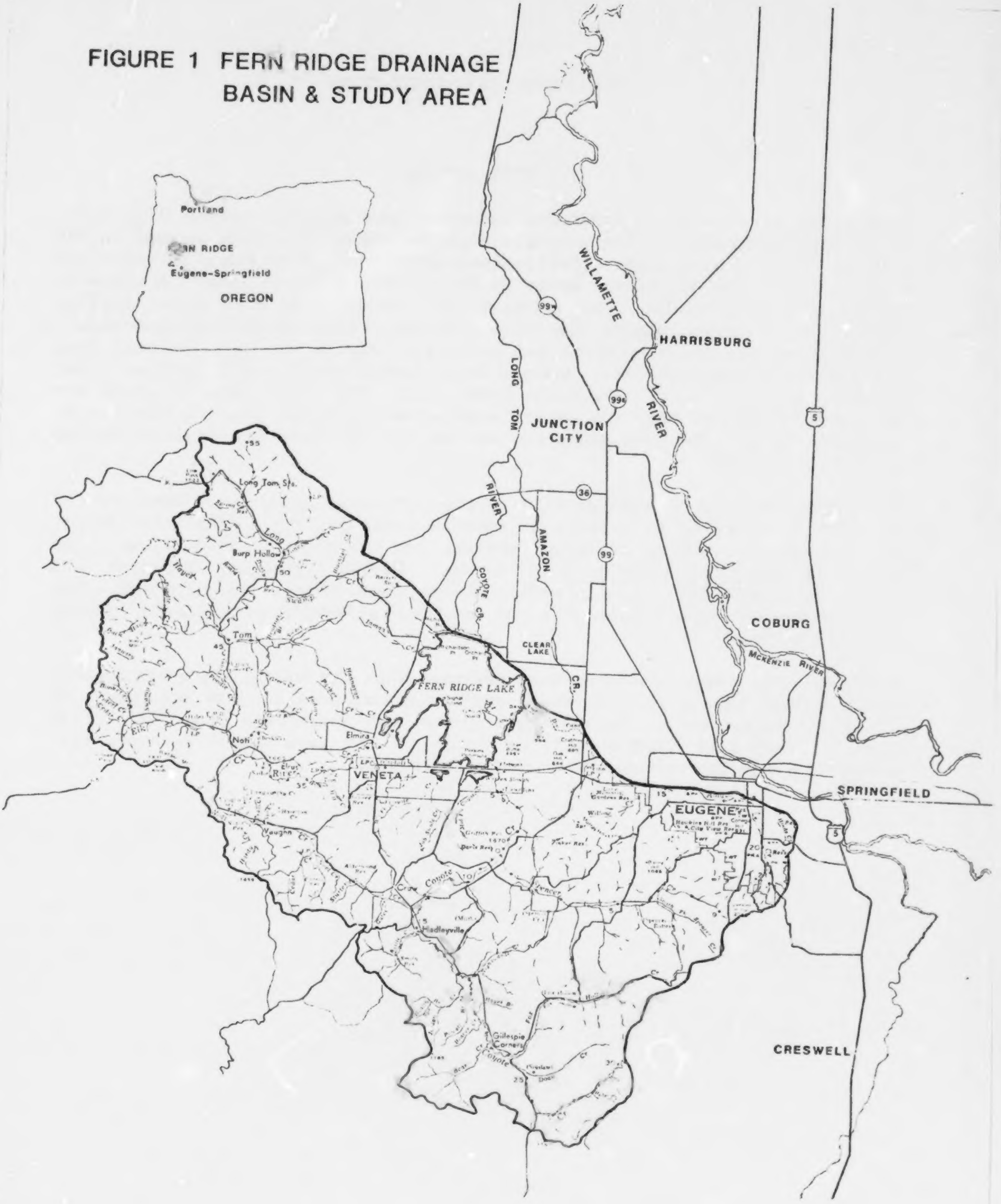
INTRODUCTION

Fern Ridge is a Corps of Engineers reservoir near Eugene, Oregon (Figure 1). It is operated primarily for recreation in the summer and flood control in the winter. It is also a major wildlife management area. Fern Ridge is among the most heavily used recreation areas in Oregon because it is large and close to Eugene and Springfield. The swimming and boating use make water quality especially important during the summer months. Lane Council of Governments investigated the water quality and pollution sources in the reservoir from March 1981 to September 1982 under a study funded by the national Clean Lakes Program (Section 314 of the Clean Water Act). The Clean Lakes programs was designed to assure that the nation's major metropolitan areas had access to swimmable lakes. The Fern Ridge project was one of seven Oregon lake studies under this program.

The project had two objectives: (1) to identify water quality problems and (2) to identify measures to restore or improve water quality. Until this study, no significant testing of water quality had occurred in Fern Ridge. The reservoir has historically been muddy. Health problems bacteria and excessive plant and algae growth problems have also been suspected. The initial lack of data resulted in the studying primarily focusing on problem identification.

Potential improvement measures were reviewed with the local, state and federal agencies that have a role in water quality enforcement or land management in the Fern Ridge basin. Recreational groups and interested individuals also provided feed back (Appendix A) on water quality improvement measures that helped to shape the recommendations of this report.

FIGURE 1 FERN RIDGE DRAINAGE BASIN & STUDY AREA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FERN RIDGE
Eugene-Springfield
OREGON
WILLAMETTE RIVER
99W
HARRISBURG
LONG TOM RIVER
99E
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JUNCTION CITY
36
AMAZON
99
COYOTE CR.
CLEAR LAKE
CR.
COBURG
McKENZIE RIVER
Long Tom Sta.
Burp Hollow
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FERN RIDGE LAKE
Elmira
Noti
VENETA
EUGENE
SPRINGFIELD
Vaughn
Crow
Coyote
Hadleyville
Gillespie Corners
CRESWELL

SECTION I. SUMMARY CONCLUSIONS AND RECOMMENDATIONS

WATER QUALITY FINDINGS

Fern Ridge is a shallow reservoir with an exceptionally flat bottom. The water level is kept high during summer months and the inflow of water is low. During winter the water level is drawn down for flood control and fluctuates and in response to high inflow from storm discharges. As a consequence, the water quality in Fern Ridge was markedly different in summer and winter. The water quality of three tributary streams also had a major bearing on reservoir quality during winter and spring.

Water Quality of Inflowing Tributaries

The Long Tom River, Coyote Creek and Amazon Channel flow into Fern Ridge Reservoir (Figure 1). The upper Long Tom River drains about 100 square miles of forest on the east side of the coast range. In spite of some urban and agricultural uses of the Long Tom, this tributary has relatively clean, clear water and rarely exceeded state water quality standards.

Coyote Creek and its tributary, Spencer Creek, drain about 100 square miles of the hills and valleys south of Eugene. Suspended solids made Coyote Creek very turbid. Monitoring of Coyote Creek consistently showed excessive contamination from livestock wastes, including both bacterial and organic loadings. The inwash of manure was so strong, following the first major fall storm of 1981, that the oxygen content was totally depleted from the water, and fish were in distress. The only time the Coyote Creek test site was bacteria-free was during July and August, when the creek channel testing site was filled with backwater from the reservoir.

The Amazon Channel drains 25 square miles from the south hills of Eugene through the city. The lower end is backed up by Fern Ridge during summer. Chemical spills and other extreme pollution sources in Eugene have occasionally caused fish kills in the Amazon Channel, near the reservoir. Sometimes the channel shows high coliform bacteria counts (less than Coyote Creek), and becomes choked with vegetation and algae. During storm flows, bacteria, heavy metals, other toxins, organic materials and litter are found in the Amazon Channel. Sediments loads were high during major winter storms.

Both Amazon Channel and Coyote Creek have little, if any, flow during summer and the problems measured in the channels were not found in the nearby open water of the reservoir. However, the backwater portions of the Amazon and Coyote Creeks are used for fishing and boating. The high coliform bacteria counts in those areas pose a potential health risk. Summer storms rarely would have enough volume to make a significant impact on the reservoir but localized short term problems from urban and agricultural runoff are possible.

Tributary storm runoff pollutants have a strong influence on the reservoir from November through April. In early winter the flow through is so rapid that there is little change in the water quality from the combined inflow to the outflow concentrations. Stream inflow occurring after February when reservoir filling begins, has the greatest influence on water quality for the coming recreational season at Fern Ridge. The nutrient load during spring is of particular concern for its influence on the growth of plankton during summer. The Long Tom River and Amazon Channel carry the highest concentrations of nitrogen. Much of the Long Tom River nitrogen load may originate from the outflow of the Veneta sewage treatment plant. Amazon Channel and Coyote Creek carry higher concentrations of phosphorus. The control of nutrient inflow may become important in future years.

Water Quality of Reservoir During Summer

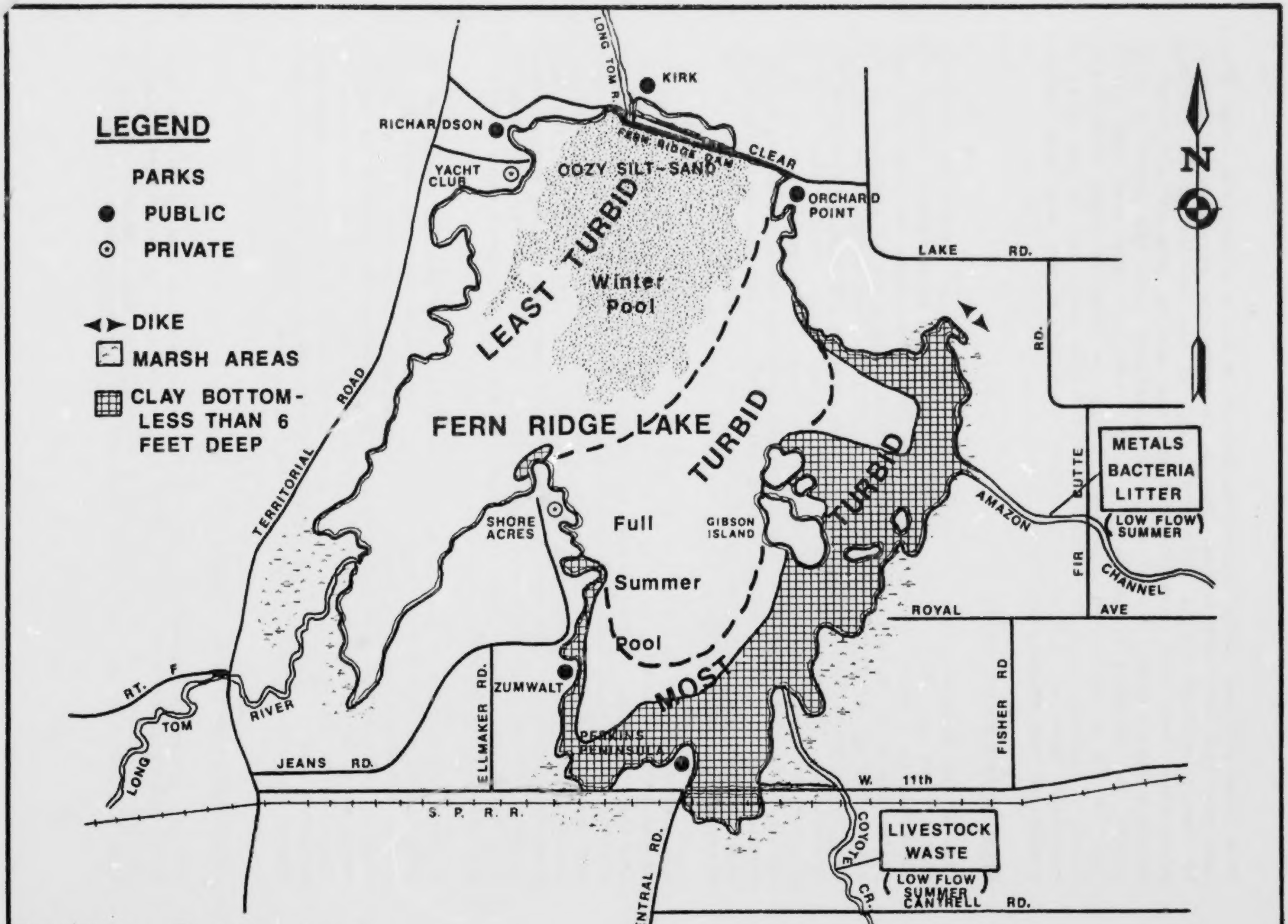
When Fern Ridge was full during summer, bacteria counts were very low throughout the lake at each testing. There was no indication of a threat to health from human or animal wastes. Testing sites did not include the beaches but a beach monitoring program set up by the Corps of Engineers did not reveal excessive levels either.

The reservoir is typically clearest in May and June. The deepest secchi disc reading during the study was 6.5 feet. By August, most of the water is so turbid that visibility is limited to a foot or two from the surface. Such turbidity is not only unsightly and unpleasant for swimming, but unsafe.

A major component of the turbidity appeared to originate from the natural clay bottom and settled silts in the shallow southeast portion of the reservoir around Perkins Peninsula Park (see Figure 2). In August fine clay particles were found throughout the reservoir, but turbidity was always greatest on the south and east sides. Heavier silts and clays are suspended and resuspended by wind waves and probably other factors such as foraging fish, motor boats and beach use. Variation in the silt load changed the clarity of the reservoir from day to day. The soft, low alkalinity character of Fern Ridge water contributes to the length of time solids remain suspended. Tests showed clays from Perkins Peninsula settled only about six inches per month in undisturbed bottles. The heavier silts settled in about two days to a week. It is evident from the laboratory studies that fine clays stirred up on one week-end will remain suspended even a month later. Waves and general lake circulation disperse the muddy water from the shallow areas to other parts of Fern Ridge.

The water is well mixed. Temperature differences from top to bottom are slight, but dissolved oxygen was occasionally depressed the bottom of the deeper areas, due to biological respiration and decomposition. The reservoir is oriented such that the southern end at Perkins Peninsula receives the fill full impact of predominant north and north-west winds. The fetch is greater than five miles.

The water level normally drops two to three feet by the end of the summer. Most of the shallow shore area is vegetated by marsh grass and bullrushes. The vegetation quiets the wave action, and their roots help bind the sediment. Aquatic plants do not grow well in Fern Ridge in water which is deeper than four feet in the spring because deeper water species can not survive the winter drawdown. By late summer, the unvegetated clay bottom areas just beyond the plants become shallower and more susceptible to disturbance from waves. The drawdown effect may be a key factor in late summer turbidity level.


LEGEND
PARKS
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⊙ PRIVATE
◄► DIKE
MARSH AREAS
▦ CLAY BOTTOM - LESS THAN 6 FEET DEEP
N
LONG TOM R.
KIRK
RICHARDSON
FERN RIDGE DAM
CLEAR
YACHT CLUB
OOZY SILT-SAND
ORCHARD POINT
LAKE RD.
RD.
LEAST TURBID
Winter Pool
TURBID
FERN RIDGE LAKE
TURBID
MOST TURBID
Full Summer Pool
SHORE ACRES
GIBSON ISLAND
TERRITORIAL ROAD
METALS BACTERIA LITTER
(LOW FLOW SUMMER)
BUTTE
FIR
AMAZON CHANNEL
ROYAL AVE
RT. F
LONG TOM RIVER
ZUMWALT
ELLMAKER RD.
PERKINS PENINSULA
FISHER RD
JEANS RD.
W. 11th
S. P. R. R.
CENTRAL RD.
COYOTE CR.
LIVESTOCK WASTE
(LOW FLOW SUMMER)
CANTRELL RD.

FIGURE 2 Problem Areas

Fern Ridge receives a high phosphorus load and a low to moderate nitrogen load each year from tributary inflow. Most of the nutrients appear to be taken up by rooted wetland plants that cover much of the shallow area. Plankton populations were not excessive although the species present indicated an enriched lake system. Low nitrogen concentrations limit the growth of algae except for nitrogen fixing species. The turbidity from suspended solids inhibits the production of algae by reducing the depth of light penetration. Plankton concentrations and fine organic particles contribute to the level of suspended material but do not appear responsible for the near opaque conditions that frequently occur.

Water Quality During Winter

Fern Ridge Reservoir has a significant increase in suspended sediment, bacteria and nutrients during winter months. Storm water flushes through the reservoir in a short time but leaves the heavier sediment and possibly some pollutants, such as lead, in the deeper areas. Old tires and other litter are also prevalent along the Amazon Channel path in Fern Ridge. The bacteria levels in winter were often ten times over state water quality standards for recreation. The water was so turbid during major storms that objects disappeared less than one foot from the surface. These problems would be of special concern if boating and other recreational use continued during winter. Since there is little access or use during winter and the accumulation of pollutants is not enough to cause problems in the summer, clear water is not necessarily a realistic goal during the flood control season.

The sediments are deposited in an oozy mix of silts on the bottom of the deeper sections of the reservoir (Figure 2) and in the deeply cut river and drainage channels. Three factors contribute to the extreme turbidity during winter: (1) a heavy loading of silt and clay is washed in from Coyote Creek and Amazon Channel; (2) silts that have accumulated in reservoir channels during summer are washed into the deeper areas; (3) with the shallower reservoir depth the silt bottom that was well submerged during summer months becomes subject to winter wave disturbance. That bottom silt was found to settle rapidly, however, and the deep silt does not present a major source of turbidity in the summer.

Extreme winter floods have deposited some sand on the shallow areas near the Long Tom River and Amazon Channel inlets. That sand helps to cover the clay bottom but there was an absences of sand deposits in the vicinity of Coyote Creek. Reducing sediment load would involve detailed investigation of erosion areas along the reservoir tributaries. Some erosion is natural, but there are areas where urban, agricultural and forest activities cause additional sediment loads. This problem appears similar to erosion problems of other rivers in the Willamette Valley and is beyond the scope of this study.

RECOMMENDED ENHANCEMENT PROGRAM

Several alternative measures could be implemented which would complement each other and ultimately arrive at a goal of cleaner water in Fern Ridge. Further testing is needed to determine which alternatives would be most effective. Some alternatives may be excluded due to cost or undesirable side effects.

Other measures, though costly, may be feasible because of benefits associated with other uses of the enhancement measure.

This study did not place a dollar figure on benefits of reducing turbidity problems at Fern Ridge Reservoir. The Corps of Engineers however, does have the obligation and executive direction to prevent their reservoir facilities from causing water quality violations. State and local interests also support the value of Fern Ridge for recreation and wildlife management. Implementation of a water quality improvement program will involve coordinated local, state and federal efforts. Toward that end, the following water quality goals and improvement program are recommended.

Water Quality Goals

The recommended goals for water quality in Fern Ridge are:

- To maintain standards that protect water contact recreation and warm water fisheries.
- To achieve water clarity that promotes public safety and aesthetic acceptability during the months of June through September.

To accomplish water clarity:

- The Environmental Quality Commission should ammend the Willamette Basin regulations to include a special seasonal management goal for Fern Ridge of achieving and maintaining an adequate secchi disc transparency readings from June through September to protect beach use (4-5 feet).
- The Corps of Engineers should adopt the transparency standard as an operation and maintenance goal and prepare a scheduled action program and budget for meeting the goals.

Recommended Action - Short Term

Improve Swimming Beaches -

Swimming beach improvements should be implemented as soon as financing is possible. Regardless of other measures taken, beaches having a clay bottom would always become turbid from swimmers use. The highest priority for improvement is Perkins Peninsula Park and then other parks depending on the conditions of beach sediment.

Initial treatment at Perkins Peninsula should include removal of litter, rocks, debris and up to one foot of the present bottom clay and replacement with a deep layer of sand. Sand with a high calcium content (limestone) should be used, if possible, since it could additionally assist in settling suspended clays.

If beach turbidity remains excessive, other treatment measures should be considered including wave dissipaters and circulation restrictors such as log booms, pile dikes or rock dikes and chemical treament of the protected beach waters to precipitate clays.

Zumwalt and Shore Acres parks require shore erosion control measures. They should be designed to be compatible with beach use and constructed as necessary to reduce local turbidity.

Funding for beach improvements could potentially come from user fees, Corps of Engineers maintenance budget, U.S.D.A. Soil Conservation Service projects or Lane County under parks maintenance.

Conduct Follow-up Studies -

Follow up studies should be conducted to plan for long term improvement strategies. The most critical study need is to determine the impact of waves on resuspending bottom material. The relationships in Fern Ridge between wind velocity and direction, wave height, depth of disturbance to bottom and sediment composition need to be established. The study should evaluate the effects of 1) maintaining a full conservation pool, 2) reducing maximum wave height by reducing the fetch at the south and east sides of the reservoir and 3) restricting boating in shallow areas. It would also indicate the optimal elevation (depth) for constructing closed cell dikes and establishing vegetation.

Field studies should be conducted to test the effect of alum, $CaCO_3$, MgO and similar compounds capable of increasing the rate of clay settling. Chloride salts would not be a practical lakewide treatment but should be tested as a means of clearing a small area in an emergency.

Further field tests should be conducted to determine whether fish activity significantly increases residue levels in Fern Ridge. The study should be designed to isolate two similar areas one with and one without bottom foraging fish species. It should be located in the southeast section of the reservoir.

These studies could be conducted in a single season. Sponsors could include the Corps of Engineers, the Environmental Protection Agency, Department of Environmental Quality, Department of Fish and Wildlife and state universities, especially Oregon State University Water Resource Engineering, Soil Science and Fisheries programs.

Correct Dairy Waste Problem -

The major livestock waste problem on Coyote Creek should be corrected. The responsible farm may require technical and financial assistance to construct necessary facilities. The DEQ and State Soil and Water Conservation Division (SWCD) should give priority attention to this problem considering the extreme bacteria, dissolved oxygen and ammonia levels that have resulted.

Recommended Actions - Long Term

Reduce Turbidity -

The Corps of Engineers should use the results of short term studies to help critically evaluate long term improvement measures. Engineering feasibility studies should be completed which identify alternate designs, estimate costs and water quality improvements and describe other impacts expected from the following proposals. The Corps of Engineers and cooperating agencies should adopt a long term program including a specific set of measures to achieve the goal of reducing turbidity. The following improvement measures are shown in Figure 3. The recommended improvements alternatives include:

- An ongoing lakewide or localized chemical treatment program,
- Construction of closed dikes cells to be used for stimulating additional growth of rooted aquatic vegetation and meeting wildlife management objectives.
- Introduction of vegetation species capable of growing on exposed flats.
- Construction of open cell dikes or islands following the submerged Royal Avenue road base and across Amazon Bay to reduce fetch and circulation of turbid water.
- Maintenance of the conservation pool elevation through flow augmentation from construction of the proposed Emerald Canal. (Feasibility evaluation would assign water quality and recreational benefits to the Emerald Canal project. Maintaining full pool would also improve sailing, access to the water and provide flexibility in the spring filling schedule.)
- Dredging selected shallow clay areas where vegetation is not feasible or desirable to a depth of minimal wave impact, and creating island cells (protected from wave attact) to dispose of the dredged material.
- Application of sand to clay bottom areas receiving significant wave impact and not being protected by other measures.
- Control of bottom foraging fish through an ongoing harvest program or elimination of species from the reservoir basin.
- Institution of a no-wake boating zone in areas most impacted by motor boat use.

Other long term water quality management activities would focus on drainage basin improvement measures. These measures should be incorporated into the appropriate state and local water quality management program.

Control Urban Runoff -

The City of Eugene should prepare an industrial/commercial site waste control ordinance and program to minimize land runoff or spills of hazardous material impacting Fern Ridge. As part of this program a spill control and containment structure should be designed and constructed for the lower Amazon. The city and Lane County should investigate the water quality implication of urban runoff in the proposed Emerald Canal/Amazon diversion concurrent with any project development or engineering studies. Water quality protection features should be included in the design. A local and state cooperative program should be developed to provide rapid response to toxic spills of all sizes.

Control Bacteria Levels -

Lane County or DEQ should monitor lower Coyote Creek and Eugene should monitor lower Amazon Channel seasonally for excessive bacteria. Major violations of water-contact recreation standards which could detrimentally affect Fern Ridge should be reported to the State Health Department and DEQ and should be investigated (traced) to identify and control specific sources.

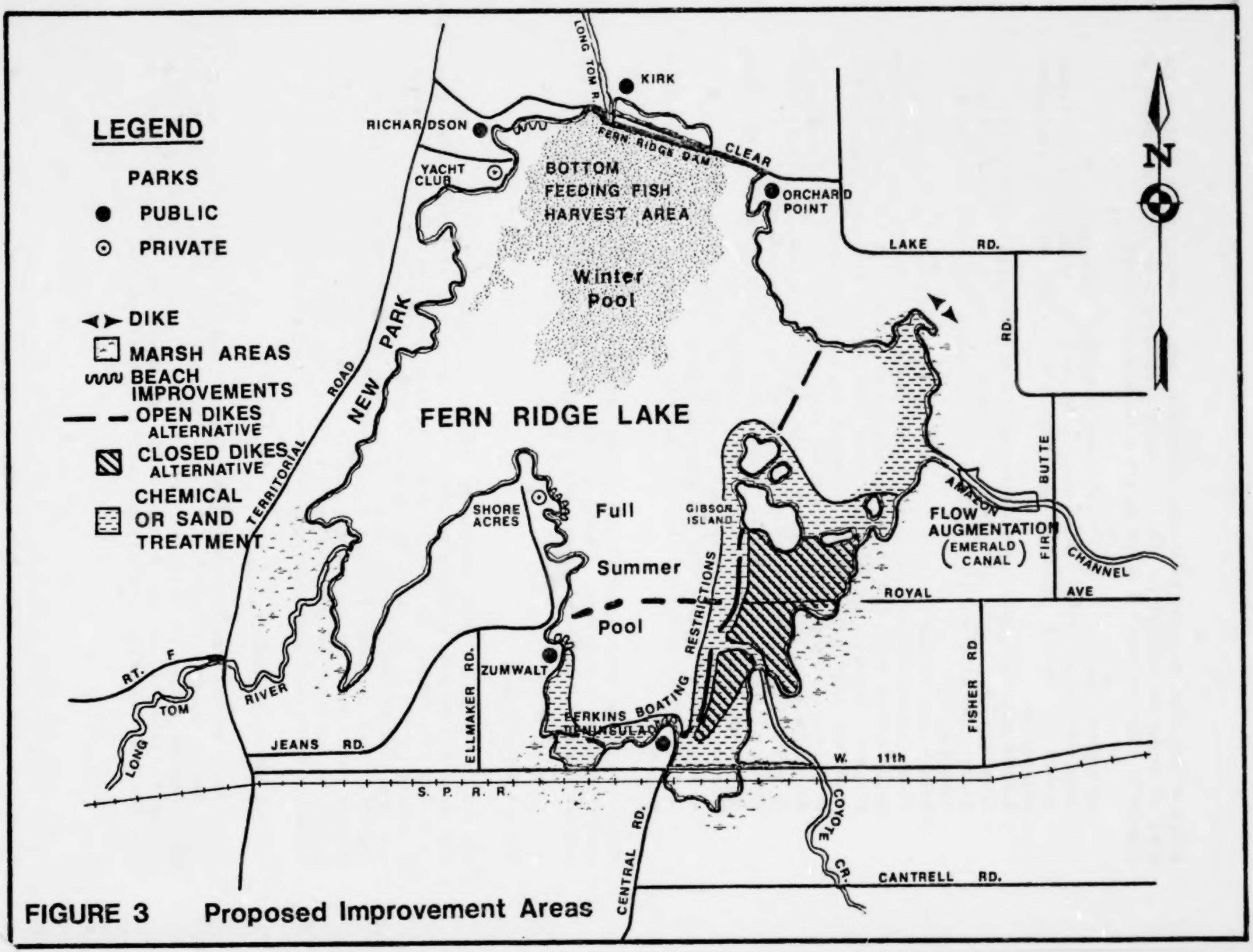
LEGEND
PARKS
● PUBLIC
⊙ PRIVATE
DIKE
MARSH AREAS
BEACH IMPROVEMENTS
OPEN DIKES ALTERNATIVE
CLOSED DIKES ALTERNATIVE
CHEMICAL OR SAND TREATMENT
N
LONG TOM R.
KIRK
RICHARDSON
YACHT CLUB
FERN RIDGE DAM
CLEAR
ORCHARD POINT
LAKE RD.
BOTTOM FEEDING FISH HARVEST AREA
Winter Pool
FERN RIDGE LAKE
NEW PARK ROAD
TERRITORIAL
RD.
BUTTE
FIR
AVE
AMAZON
CHANNEL
FLOW AUGMENTATION (EMERALD CANAL)
ROYAL
FISHER RD
SHORE ACRES
Full
Summer
Pool
GIBSON ISLAND
RESTRICTIONS
BOATING
ZUMWALT
PERKINS PENINSULA
ELLMAKER RD.
JEANS RD.
RT. F
RIVER
TOM
LONG
W. 11th
S. P. R. R.
CENTRAL RD.
COYOTE CR.
CANTRELL RD.

FIGURE 3 Proposed Improvement Areas

The SWCD should implement a livestock waste control program in the Coyote Creek basin if excessive bacteria levels persist following elimination of the one known source. The program should survey livestock waste facilities and specify disposal or management systems for individual farms.

SECTION II. RESERVOIR RESOURCES

AUTHORIZED RESERVOIR USES

All major multiple-use reservoirs of the Corps of Engineers were constructed and funded on the basis of benefits derived from specific uses authorized by the U.S. Congress. The authorized uses of Fern Ridge are flood control, irrigation water storage and navigation in the Willamette River. They have priority over the non-authorized uses and flood control also has priority over the other authorized uses in case of conflict. At the time of the authorization of Fern Ridge, recreation, fish and wildlife use and low flow augmentation for water quality were not recognized as uses of national significance and consequently were not included as official uses to base reservoir operation upon. Within the authorized uses summer storage must be released to:

not [illegible] [illegible]

> "1) maintain downstream flows in the Long Tom River (50 cubic feet per second to July 1, 30 cubic feet per second from July 1 to November 15;
> 2) satisfy irrigation demands under the terms of contracts between the Bureau of Reclamation and respective irrigaters; and
> 3) assist in maintaining adequate flows for navigation in the Willamette River from Corvallis to Albany." (Corps 1973)

The primary flood control season is November 16 to January 31. The reservoir is drawn down during that period to provide maximum storage capacity. Flood water is released as rapidly as possible while still minimizing downstream flood impacts so that the capacity is available for subsequent floods. The period of filling is February 1 to April 15 and the holding and release season is April 16 to November 15. Filling occurs earlier in Fern Ridge than other reservoirs because of the lack of snow pack in the reservoir drainage area.

In practice, the Corps has not had to make releases for irrigation beyond the minimum releases for flow maintenance in the Long Tom. Irrigation contracts if fully exercised could result in strong conflicts between irrigational and recreational interests. In addition, such draw downs would subject the unvegetated reservoir bottom to greater wave disturbance, and more turbidity.

The navigation authorization for flow augmentation has evolved into a water quality augmentation since navigation has ceased in the Willamette River above the Oregon City falls. The Corps has elected not to make releases from Fern Ridge for such augmentation because of the extensive recreational use and because the water is so warm it would not improve Willamette River conditions.

In general, the Corps has balanced the operation of Upper Willamette Reservoirs so that Fern Ridge provides the maximum opportunity for recreation possible considering flood control requirements. Occasionally this has also resulted in less than adequate flow releases for fish life below the dam. Each of the reservoir uses imposes constraints or has conflicting demands for reservoir elevation or flow releases. The water quality findings will be geared toward the three reservoir operation seasons. The restoration measures are examined in terms of resource use conflicts and benefits.

PHYSICAL SETTING

wetlands?

Fern Ridge is physically much different than any other Corps of Engineers reservoir in the Willamette River Basin. Originally, it was a flat swampy portion of the valley floor ten miles from Eugene. A long, low dam and supplementary dikes were required to contain the reservoir. At full conservation pool during summer months it is 5.5 miles long and 5.0 miles wide, and covers about 15 square miles but averages just 12.5 feet deep. The maximum depth is 30 feet. Major shore-line features include two peninsulas, Perkins and Jeans, and one large island, Gibson Island, which has several small low islands around it.

Figure 4 shows generalized five foot contours of the reservoir prior to construction of the dam. Some contour changes have occurred as a result of channeling along Highway 126, the Long Tom River and diverting Amazon Channel into to the reservoir. These channel changes have been accompanied by changes from erosion and sedimentation within the reservoir. They are not fully documented but can be generally located from aerial photographs.

Fern Ridge dam crosses the Long Tom River 23.6 miles above its confluence with the Willamette River. The dam also cuts off the Coyote Creek channel but the spillway was only built into the Long Tom River. The reservoir is filled primarily by inflow from the Long Tom River and Coyote Creek but about ten percent of inflow comes from the Amazon Channel basin and the small direct drainage basins shown on Figure 5. The total land area draining into Fern Ridge is 275 square miles. Generally, all streams except the Long Tom dry up in the late summer. The reservoir level drops by 1.5 to 3.0 feet over the summer, because evaporation, irrigation and downstream minimum flow releases exceed the inflow. The minimum winter pool elevation (353 feet) maintained for flood control is 20 feet lower than the conservation/recreation pool (373.5 feet) maintained in the summer and only contains six percent of the volume of water. Winter drawdown leaves extensive mud flats exposed. Stream flows generally pass through the reservoir in less than a week during winter. Much of the inflow passes through in the deeply etched historic channels until it reaches the reservoir level. The flats are periodically exposed to wind waves when the reservoir level raises and lowers.

RECREATIONAL RESOURCES

Fern Ridge Reservoir has among the most heavily used recreation facilities in Oregon and provides for a variety of uses, including swimming, sunbathing, picnicking, all forms of boating, fishing, and assorted other activities. For most activities, users come mainly from the local area (Eugene, Junction City, Veneta, Springfield), but sailors are also attracted from further away due to the paucity of good sailing waters in Oregon. The reservoir size and proximity to the metropolitan population of Lane County result in annual park usage of 1 to 1.5 million recreational user days.

5 parks

Three public parks (Figure 2), Orchard Point, Richardson-Kruger and Perkins Penninsula are developed for high density use. Two other parks are less developed, Kirk Park around the ponds below the dam, and Zumwalt Park, which was being more intensively developed when budget problems resulted in abandoning the facilities in 1981 and 82. Lane County operates Orchard Point,

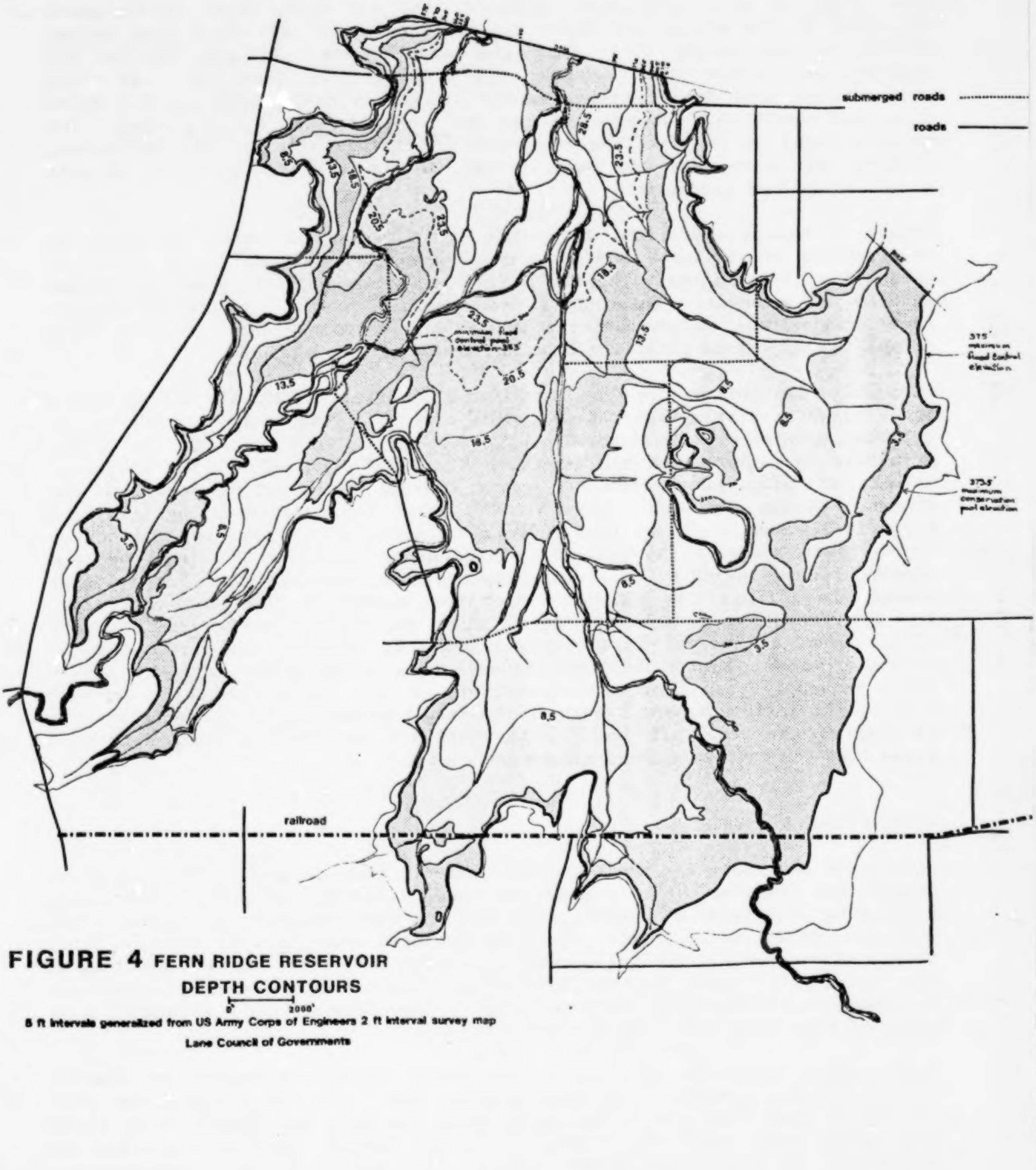
submerged roads
roads
railroad
375' maximum flood control elevation
373.5' maximum conservation pool elevation
minimum flood control pool elevation
3.5
8.5
13.5
18.5
20.5
23.5
28.5
0' 2000'

FIGURE 4 FERN RIDGE RESERVOIR DEPTH CONTOURS

5 ft intervals generalized from US Army Corps of Engineers 2 ft interval survey map

Lane Council of Governments

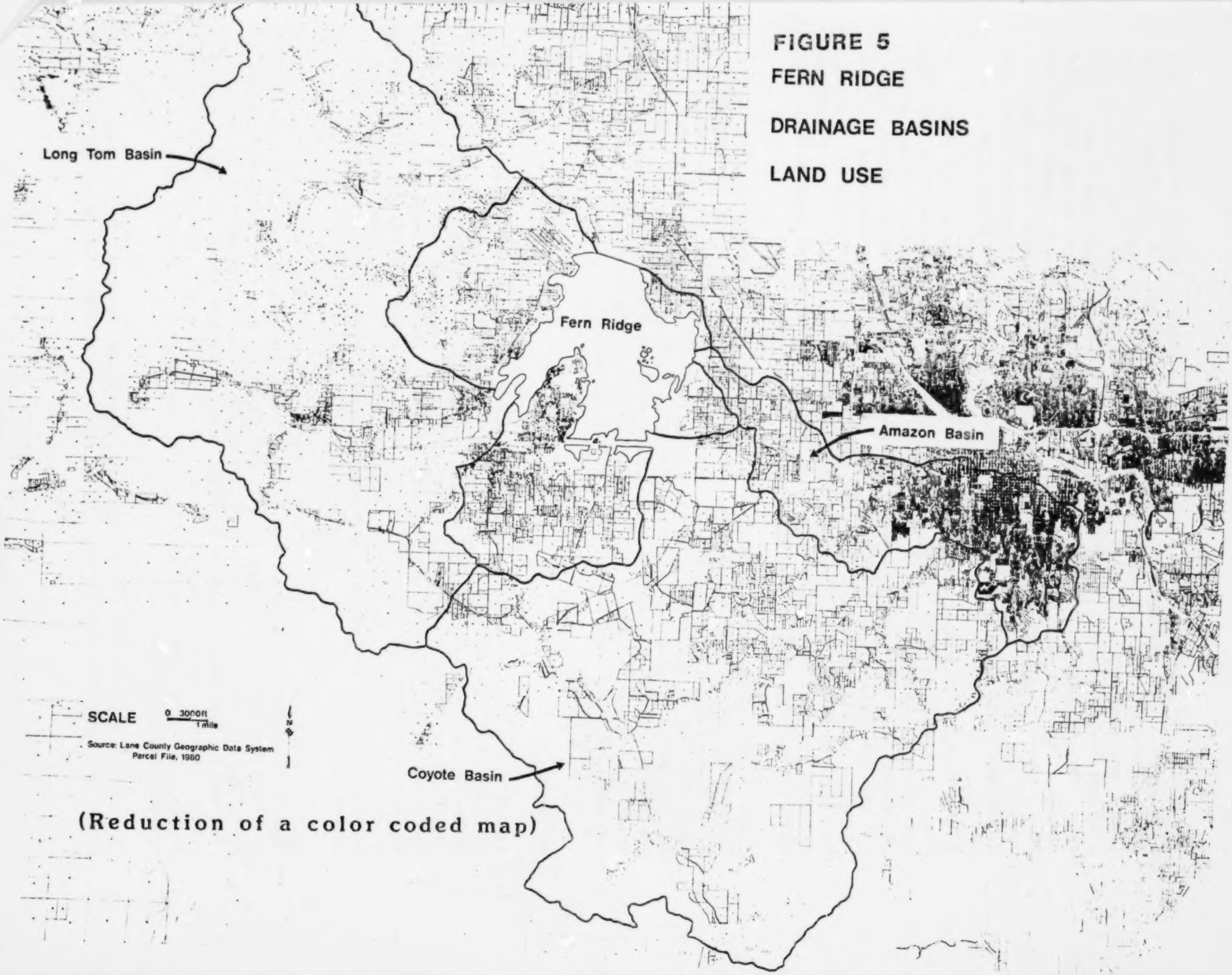

FIGURE 5
FERN RIDGE
DRAINAGE BASINS
LAND USE

Long Tom Basin
Fern Ridge
Amazon Basin
Coyote Basin
SCALE
0 3000ft
1 mile
N

Source: Lane County Geographic Data System Parcel File, 1980

(Reduction of a color coded map)

Richardson and Zumwalt parks while the Corps operates Perkins Peninsula and Kirk parks. Lane County has proposed returning Zumwalt to the Corps. There is one private park and campground, Shore Acres, and three facilities are leased and operated by private organizations; Eugene Yacht Club, Tripass Ski Club and Oregon Aqua Skippers. Numerous other access points, trails and parks exist or are planned. Parking areas have been installed along West 11th Avenue to provide access for fishing from the bank. Recent trends indicate that reservoir use has leveled off since the dramatic growth during the late sixties and early seventies. Imposition of parking fees at Orchard Point and Richardson Parks appears to be a major factor influencing the level of use.

A survey of Fern Ridge users was conducted one Sunday during the summer of 1981, as a part of this study. Results (Appendix A) indicated that swimming was the most universal use of the reservoir. Sunbathing, picnicking, social gathering and rest and relaxation followed. Sailing, motorboating, water skiing, and fishing were frequent uses. Other activities mentioned included camping, wildlife observation and nature walks, non-motorized boating, hunting, exploring mud flats and dog training. Over half of the people we surveyed believed there was a water quality problem and even more said if the water was cleaner they would use Fern Ridge more often.

Flood control and most recreational activities are mutually conflicting in Fern Ridge because even a small drawdown of the reservoir from the recreation pool (five feet or more) makes the water inaccessible except at the dam. Even that site has no developed low water ramp. The present practice is to begin filling the reservoir for recreational use in February and complete filling by mid-April. The recreational conservation pool is kept as full as possible until the end of September. It is then drained by mid-November to the minimum pool level and operated for flood control until February.

WETLANDS

Nearly all of the areas of Fern Ridge that are shallower than three feet deep at full pool are densely vegetated. Emergent plants including reed canary grass, Phalaris arundinacea; bull rush, Scirpus validus and cattail, Typha latifolia predominate in these areas. Reed canary grass has been expanding its coverage and crowding out the bull rush and cattails in many areas. It is an inferior food and cover plant for water fowl and efforts are planned to reduce its extent. In a few areas submergent vegetation predominates. Reservoir level fluxuation, however, prevents plant establishment in most deeper locations.

Approximately one quarter of the reservoir is 3 feet deep or less and vegetated with the emergent marsh plants. Many other acres of marsh and shrub wetlands are located on Corps of Engineer property above the conservation pool elevation of 373.5 up to an elevation of 380 feet. Those marshes are located adjacent to the lower wetlands on flat, poorly drained soils that pond during winter rains. Another eight percent of the reservoir (generally slightly deeper) contains open patches of vegetation (mostly bullrush) and sparsely spaced submergent plants.

This large expanse of rooted wetland vegetation consumes large amounts of plant nutrients and appears to leaves little available for plankton growth.

It also serves as a critical wave buffer which protects the shoreline from erosion and reduces the force of waves on the shallow bottom. The annual drawdown of the reservoir exposes the bottom to killing winter frosts which few deepwater aquatic plants can survive. Thus, two-thirds of the reservoir is essentially devoid of macrovegetation even though much of it is shallow enough to support rooted plants.

The wetlands at the south and west sides of the reservoir provide excellent habitat for many kinds of birds. Most of those areas are managed for wildlife use by the Oregon Department of Fish and Wildlife (ODFW) or as natural areas by the Corps. The water level fluctuation in the reservoir however, makes a less than optimal habitat for nesting water fowl and the fall shorebirds migration (July-October). A series of dikes and grain fields has been developed on higher Corps property to actively attract water fowl. Additional activities are planned to provide nesting mounds for water fowl and ODFW has proposed locating dikes within the reservoir to improve wildlife habitat. Several birds which are not common in the Willamette Valley reside in the Fern Ridge area. Examples include bald eagles, osprey, great egret, sora, Virginia rail, American bitterns, and yellowheaded blackbirds. The area near Royal Avenue is especially popular for bird watching. The Audubon Society and Oregon Field Ornithologists maintain lists of bird sightings.

The production of mosquitos from the wetland areas of Fern Ridge adjacent to park and residential development causes local concern. The county has in the past implemented various chemical and biological means of pest control. Mosquito eggs successfully hatch and emerge as adults in quiet wetted areas generally up to one foot deep. The spring filling schedule appeared to have a strong bearing on the mosquito population. Lane County requested that the Corps of Engineers abandon the experimental practice of over filling the reservoir in the spring (to provide more water for late summer) because of the problem associated with the additional mosquito habitat.

FISHES

The lake is populated largely by carp, suckers, bullhead, crappie and largemouth bass. The carp, bullheads ("catfish") and suckers are all bottom foraging species which have been identified as contributors to turbidity problems in other areas. Bluegill, other warm water game fish and trout are also reported in low numbers. For the most part, fishing takes place in shallow areas, near shore and at the places where stream channels enter the reservoir. During winter, fishing is concentrated near the dam. Much of the fishing associated with Fern Ridge however, takes place immediately below the dam in the Long Tom River and the large borrow pit at Kirk Park. Minimum releases from the reservoir are required during summer to sustain fish life in the Long Tom River. Reservoir elevation affects the fishing success within the reservoir. At full pool, many fish hide in the densely vegetated areas that are normally unfishable. Lower levels draw the fish into the open water.

HISTORICAL-ARCHEOLOGICAL

Native Americans and early settlers were attracted to the reservoir site by the plentiful fish and game populations in the original rivers and wetlands. Several mounds containing artifacts are known to exist within and around Fern Ridge. In addition, a section of the historical Applegate Trail, used originally by the Calapooya Indians and later by settlers and wagon trains, was located in the reservoir (Corps 1973). These resources have not been systematically studied and any proposed physical changes in the reservoir such as dredging and diking, should be preceeded by examination of impacted historical or archeological resources.

1941

SECTION III. INVENTORY AND MONITORING

OBJECTIVES

A water quality enhancement program ideally is designed with an understanding of the existing problems and pollution sources. Ultimate quality goals are based on the requirements of the primary uses of the water. The user requirements are balanced by natural factors controlling water quality and the economic, social and environmental consequences of enhancement proposals.

Common knowledge and recollections of long-time users indicate Fern Ridge has been a "dirty" reservoir since it was completed in 1941. However, until this study, no technical assessment had been made of the actual water quality and causes of the turbidity problem. Brief sampling by the Oregon Department Environmental Quality (DEQ) suggested that turbidity from suspended sediment and plankton, high temperature and evoporation loss due to shallow depth, and odor problems from blue green algae growth could all be major problems. These reports (McHugh 1972 and McHugh 1979) suggested that massive reservoir dredging and filling was the only long range means of improving the water quality.

The three primary uses of Fern Ridge are recreation, flood control and fish and wildlife habitat. Irrigation is a minor use, but with avid interests in maintaining its status. The reservoir has no power facilities, but utilities are studying the feasibility of retrofitting the dam for hydropower. Future irrigation or power development would require additional assessment of water quality needs and impacts.

Water quality mainly affects swimming, boating, fishing, and aesthetic uses during summer. The water quality during winter may affect wildlife usage but has little bearing on winter activities at the reservoir, which include nature observation, searching for Indian artifacts, hunting, trap shooting, dog training and limited bank fishing. Therefore the summer use provides the main focus for determining desired water quality.

The inventory and monitoring program was designed to broadly determine what water quality problems existed and then to focus on the sources of major problems. The inventory covered existing data and mapping of the physical characteristics, land use and known pollution sources in Fern Ridge and its drainage basin. Monitoring included basic water chemical analysis, and special studies of the sediments, suspended clay minerals, primary production, and species identification for plankton.

As monitoring proceeded it became apparent that turbidity was the critical problem during summer. Suspended silt and clay was a major cause of the turbidity. The initial inventory and monitoring indicated Coyote Creek and the reservoir bottom were the main potential sources of clay minerals. Special monitoring programs then were set up to investigate daily wave impacts near Perkins Peninsula, and to survey the reservoir flats during winter. The final monitoring objective was to examine the relationship between the turbidity of water filling Fern Ridge and the turbidity of the full reservoir. The flexible approach to monitoring provided a wide range of monitoring data while permitting more detailed focus on the primary problems found. If eutrophication and algal blooms, or excessive bacteria had been found in the lake, additional surveys would have concentrated on those problems.

MONITORING SITES

Water quality monitoring stations (Figure 6) were located near the head of stream influence by the reservoir on the three major incoming streams: Long Tom River, Coyote Creek and Amazon Diversion Channel. Two special short term stations were set up above the Coyote Creek station to examine livestock waste sources. Samples were also normally collected from the Long Tom River below Fern Ridge dam. The river stations were monitored once a month between March, 1981 and February 1982 and twice monthly in March and April 1982.

Five stations were set up in Fern Ridge (Figure 6). Three were located in areas influenced by the streams. One was influenced by a small drainage and Perkins Peninsula and Zumwalt parks. The main year round station was located in the middle of the minimum pool area. The sites were named Amazon Bay (FR-AB), Coyote Bay (FR-CB), Perkins Bay (FR-PB), Long Tom Bay (FR-LB) and pool (FR-PO). The "Bay" names are not in common usage, but will be used in this report.

The location of monitoring sites permitted us to determine whether spatial differences in water quality existed and whether differences could be related to the incoming water. The shallower lake monitoring sites were located far enough from shore that they avoided localized effects of shore activities, such as heavy beach use.

DRAINAGE BASIN INVENTORY AND MONITORING METHODS

Watershed pollution sources were both inventoried and monitored through tributary sampling. The Fern Ridge drainage basin was delineated on U.S. Geological Survey 15 minute topographic maps. Sub-basins (Figure 5) were drawn for the upper Long Tom River, Coyote Creek and Amazon Diversion Channel. Several other small creeks in the Veneta-Elmira area drain directly into the reservoir. They were grouped together as direct drainage for land use assessment.

A general land use inventory was completed using the Lane County computerized geographic data base. A computor generated map of individual parcels (Figure 5) was produced that was color coded to land use. Basin boundaries were drawn on the one inch to 3000 foot scale map. Forest, agriculture, urban, and rural residential acreages were determined by planimeter from the computor plot. The land use breakdown gave a general idea of the type of non-point (land runoff) pollution problems expected.

Since turbidity was a major problem of concern at Fern Ridge it was necessary to determine the erosion potential in the drainage basin. Oregon's Procedure for Assessing the Impacts of Land Management Activities on Erosion Related Nonpoint Source Problems (Rickert, et al. 1978) was loosely followed. A slope map showing 0-12%, 12-35%, 35-60% and greater than 60% ranges was completed and used for the analysis. The minimum measurement resolution was 5 to 10 acres. General geologic and soils association maps were also put together to

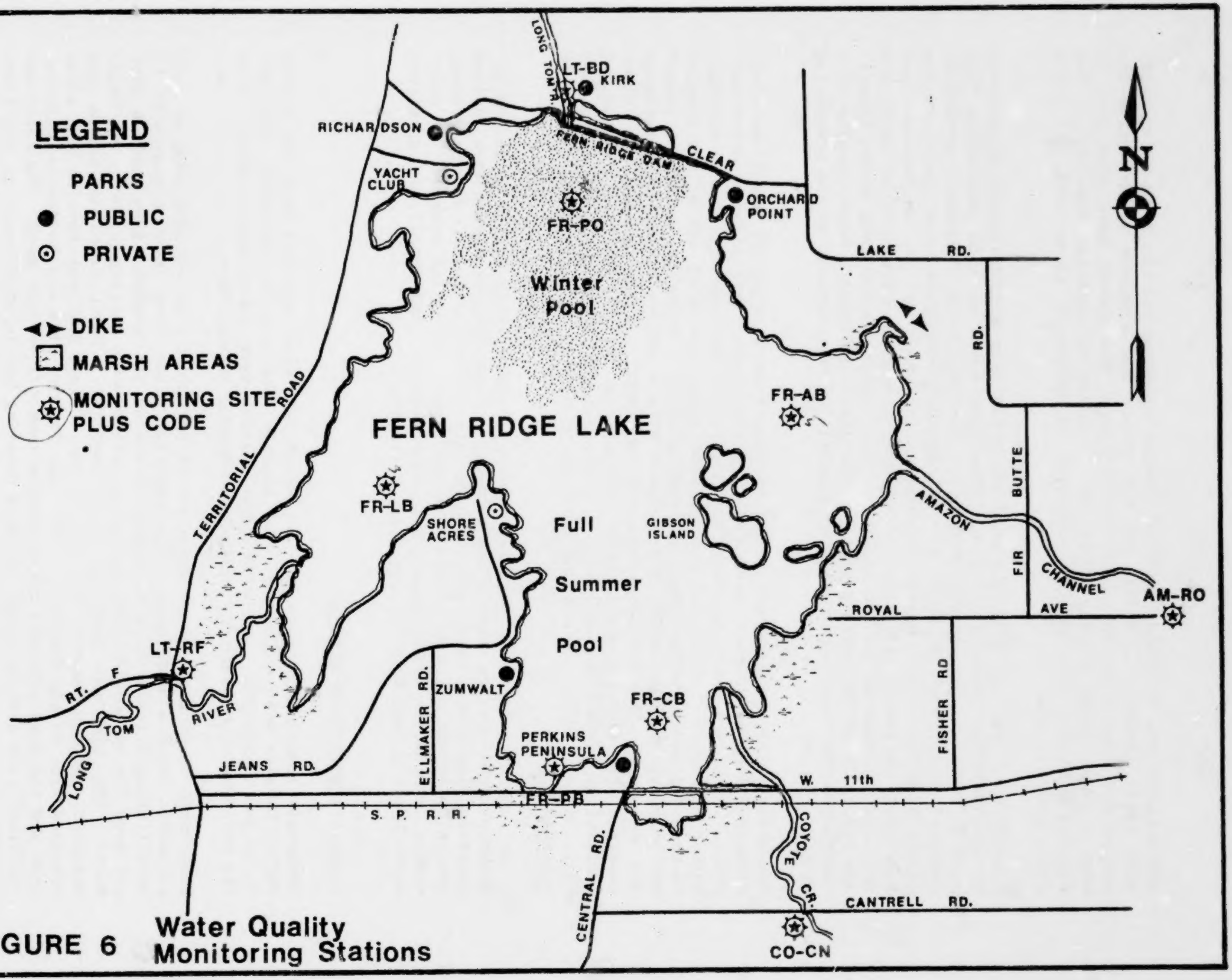
LEGEND
PARKS
● PUBLIC
⊙ PRIVATE
DIKE
MARSH AREAS
MONITORING SITE PLUS CODE
FERN RIDGE LAKE
Winter Pool
Full Summer Pool
LONG TOM R.
LT-BD
KIRK
RICHARDSON
YACHT CLUB
FERN RIDGE DAM
CLEAR
ORCHARD POINT
LAKE RD.
FR-PO
FR-AB
FR-LB
FR-CB
FR-PB
SHORE ACRES
GIBSON ISLAND
TERRITORIAL ROAD
RD.
BUTTE
FIR
AMAZON
CHANNEL
AM-RO
ROYAL
AVE
LT-RF
RT. F
RIVER
LONG TOM
JEANS RD.
ELLMAKER RD.
ZUMWALT
PERKINS PENINSULA
FISHER RD
W. 11th
S. P. R. R.
CENTRAL RD.
COYOTE CR.
CANTRELL RD.
CO-CN
N

FIGURE 6 Water Quality Monitoring Stations

characterize the type and extent of erosion expected and the sediment material that would result. A series of air photos was examined to determine the extent and rate of recent clear-cut logging. The photos were also used to make a generalized assessment of the condition of riparian vegetation. The erosion potential findings are detailed in Section V along with the other drainage basin data.

Land-based loads of pollutants were estimated from physical/chemical analysis of the tributary water quality and flow data based on USGS continuous flow records near the monitoring stations. The twenty-six different parameters measured are listed in Table 1. All bacteria analyses were based on the coliform group. The water characteristics such as pH, conductance and alkalinity influence the impact of sediments, organic wastes, plant nutrients and toxic substances on the water quality. During summer both Amazon Channel and Coyote Creek had periods with no flow into Fern Ridge. Water samples were taken from the reservoir backwater that filled the channels at the monitoring stations.

Tributary water samples were taken by hand from a depth of about one foot. Dissolved oxygen samples were fixed in the field. All other samples were stored in coolers and returned to the laboratory for stabilization or analysis within six hours. Duplicate samples were taken for about 10% of the samples to assess laboratory test precision and accuracy. A quality assurance report was prepared for the study, and Appendix B is a summary of testing procedures and accuracy. The laboratory procedures apply to lake as well as river samples. The laboratory data were entered into the EPA STORET data system and statistical evaluations were completed through STORET and at L-COG using SPSS (Nie, et al. 1975). The STORET station retrieval information is listed in Appendix C.

Point source waste discharge permits were located for the entire basin. Other point sources are not mapped but probably include include septic tank failure contaminating ground water which drains into the reservoir. Tributary streams generally do not carry point source waste discharges in the summer. The point source information allow some distinction between land runoff and permitted waste loads in tributary water quality statistics.

RESERVOIR MONITORING METHODS

Reservoir monitoring began in late March 1981 when the reservoir was nearly full. Samples were collected twice monthly from June to September, 1981 and March and April 1982. At other times samples were taken once a month. Only the pool monitoring site had water from November through March.

From March to September 1981 and again in April and June of 1982 samples were collected from a motorboat. The sampling sites were located generally by establishing triangulation reference points on the shores. Buoy markers were not used due to the likelihood of interference with boating activity and being moved. The boat was anchored while sampling. Total depth to bottom was measured. During summer the Amazon Bay, Coyote Bay and Perkins Bay sites averaged five to six feet deep. The Long Tom Bay site was twelve to thirteen feet and the pool site was twenty-two to twenty-five feet deep. The water was collected with a three liter Van Dorn sampling bottle at a depth of two feet. An additional sample was taken two feet above the bottom of the pool station.

TABLE 1. WATER QUALITY PARAMETERS

PARAMETER	UNIT
Water Temperature	°C
Reservoir Surface Elevation	feet above sea level
Tributary Flow	cubic feet per second
Turbidity	NTU
Transparency	secchi disc inches
Conductivity	Micromhos at 25°C
Dissolved Oxygen	mg/l
Biochemical Oxygen Demand (ultimate)	mg/l
Chemical Oxygen Demand (low level)	mg/l
pH	Standard Units
Total Alkalinity	mg/l - CaCO3
Total Residue	mg/l
Total Nonfilterable Residue	mg/l
Settleable Residue	ml/l
Ammonia (NH_3+NH_4)	mg/l - total N
Nitrite - Nitrate	mg/l - total N
Total Phosphorus	mg/l - P
Total Hardness	mg/l CaCO3
Chloride	mg/l
Sulfate	mg/l
Arsenic	ug/l
Iron	ug/l
Lead	ug/l
Total coliform bacteria	/100ML MFIMENDO
Fecal coliform bacteria	/100ML MFM-FCBR
Chlorophyl-a	ug/l corrected
Orthophosphorus	mg/l - P

Winter and spring of 1982 sampling was a bit more difficult. With the reservoir drawn down access was gained by launching a canoe at the the dam. Waves were frequently over a foot high which either precluded use of the canoe or added an element of excitement into the sampling operation. Surface samples were taken by dipping the sample bottles from the canoe rather than using the Van Dorn sampler. When it was impossible to go out in the canoe, samples were taken from the dam by casting the Van Dorn bottle out from the shore. Samples were collected from both sides of the spillway because the incoming water from Coyote Creek and Long Tom River were not well mixed in winter.

A Presto-Tek portable water laboratory meter with probes on a 25 foot cable extension was used to take field measurement of temperature, pH, conductance and occasionally dissolved oxygen. Those readings permitted immediate determination of a thermocline or layered system. Although the meter was calibrated immediately prior to most sampling trips, a significant difference between laboratory and field meter results nearly always existed, with field meter readings generally being lower. The gradient for temperature, conductance and pH over depth, however, was very close for field and laboratory measurement. So the field measurement provided a good view of surface to bottom differences.

Several biological tests were conducted on the reservoir water in addition to the parameters measured in the rivers. Chlorophyl-a which is the primary pigment tissue in algae and can be related to the amount of algae present was measured. Phytoplankton and zooplankton were also enumerated and keyed to their genus. The primary production of plankton was measured on three occasions at the pool station. The oxygen evolution method using light and dark bottles suspended at various depths was used for that test. Production monitoring was completed during mid-day with incubation times of four to six hours. The biological results are summarized in Section VI.

An analysis of the clay suspended in Fern Ridge was also essential to defining the turbidity problem. Dr. M. E. Harward, Department of Soil Science, Oregon State University completed X-ray diffraction analysis of the lakes suspended sediments for this study. He determined the general character of the clay size fraction and which clay minerals were predominant. His detailed report is in Appendix D and results are discussed in section VI.

The impact of wind waves on turbidity was studied by taking measurements over an entire day, for transparancy, turbidity and residues. A transect of four stations (with depths of three feet to ten feet) was set up east of Perkins Peninsula to the west side of Gibson Island. A marker was driven into the sediment to measure wave height. The test was run on two separate days. Unfortunately the maximum wave height on either day (6 am to 6 pm) was 0.3 feet. Nonetheless, the data collected led to some conjectures about the nature of suspended material and the sources of bottom disturbance.

The reservoir bottom was surveyed by walking across the flats during the winter. General observations of sediment condition were recorded in notebooks. Several samples were taken with shovel or spatula from the top mixed layer (about one to two inches) and from obvious native soils five to ten inches deep. Samples were kept in separate ziploc bags and partical size distribution analysis was completed on each. Several sediment samples were also collected by boat from the bottom of the permanent pool using a Petersen grab sampler. These samples were subjected to the same analysis as the sediments from the flats.

The size distribution analysis included both wet seiving and dry seiving. Subsamples were weighed, dried and reweighed to determine moisture content. Then 100 to 200 grams of each wet sample was washed over a standard 63 micron sieve to remove most of the silt-clay fraction (wet seiving). The remaining sediments were dried and sifted through a series of standard seive sizes for 10 minutes in an automatic shaker. The silt-clay fraction was computed by determining the dry wet of silt and clay that was washed away during wet seiving and adding it to the clay/silt fraction from the dry seiving.

Several sediment samples were also mixed with tap water and stored in tall sample bottles and allowed to settle undisturbed. The visual progression of settling was recorded. These tests gave an approximation of the settling rate of the lake bottom material, and what occurs when it is disturbed.

Monitoring did not extend to some other possible factors in lake quality including the waste loads from recreation activities, disturbance at the bottom from boats or beach users, shoreline erosion, extent of wetland vegetation and fish species. Those factors were superficially examined using existing information and inventories especially, the Fern Ridge Lake Master Plan by the Corps of Engineers (1973).

SECTION IV. WATERSHED POLLUTION SOURCES

BASIN CHARACTERISTICS AND LAND USE

The 275 square miles that drain into Fern Ridge (Figure 5) are predominately gently sloped coastal mountains or flat alluvial plains. Less than two percent of the basin is steeper than 65 percent slopes. Soils, precipitation and slopes vary distinctly from one river drainage to another and land use is closely tied to the geographic features.

The upper Long Tom River basin is the least populated and most steeply sloped. Slopes in the western half of the basin are predominantly 35 to 65 percent and elsewhere they are generally less than 35 percent. The major tributaries are Noti Creek and Poodle Creek. The sub-basin receives the most annual precipitation (45-65 inches). The upper Long Tom comprises 39 percent of the Fern Ridge basin. About 84 percent is in forestry use including several sections under Bureau of Land Management ownership and 12 percent is in agricultural use (Table 2). The developed areas include Elmira, Noti, Vaughn and part of Veneta. In some areas, river valleys have been subdivided into small acreages that are classified as rural residential in this study. The actual use may include both farm and forest use. Urban and rural residential use covers less than four percent of the basin.

There are three permited waste discharges into the Long Tom River including treated sewage discharge from Veneta and log pond discharge from mills at Vaughn and Noti. The 1979 average waste loads from Veneta are listed in Table 3. Nitrogen levels are not specified but generally average 20-30 mg/l in treated sewage. The maximum combined permitted level of BOD from the mills is 225 lb/day. They are located over eight miles from the reservoir and the residual waste at Fern Ridge is probably minimal. Additional contributions could arise from the developed areas that rely upon on-site sewage disposal systems.

The Coyote Creek basin contains a mix of forest, agricultural and rural residential use. This basin is essentially the same size as the Long Tom but more gently sloped and receives less rainfall (38-50 inches annually). Spencer Creek is the only major tributary to Coyote Creek and in spite of severe groundwater limitations a significant portion of the Spencer Creek basin is subdivided for rural residential use. A small area near the ridge top of Spencer Creek basin along southwest Eugene is developed with urban services for residential use. This constitutes the only urban development in the Coyote Creek Basin. Over half of the basin is forest land and about one third is agricultural (Table 2). Most of the agriculture is livestock and dairy, with pasture rather than crop development. The forest land is mostly on gentle slopes of 12-35 percent and most agricultural areas have a slope of less than a 12 percent.

The Amazon Diversion Channel basin includes less than nine percent of the Fern Ridge basin but since over half is within the City of Eugene (Table 2) it constitutes a significant potential pollution source. Much of the basin is flat valley floor but gentle hills form the southern and eastern boundaries. The non-urbanized hillsides include mostly forest and rural residential use. The flat lands west of Eugene are agricultural pastures, grass seed and some

TABLE 2. LAND USE DISTRIBUTION IN THE FERN RIDGE BASIN

		Corps	Urban	Rural	Agric.	Forest	Total
Long Tom River	Sq. Mi.	0.5	1.1	2.6	12.7	91.1	108
	%	0.5	1.0	2.4	11.8	84.4	100/39.3
Coyote Creek	Sq. Mi.	1.0	0.7	6.6	36.9	61.8	107
	%	0.95	0.65	6.2	34.5	57.7	100/38.9
Amazon Diversion Channel	Sq. Mi.	0.1	12.4	3.4	5.9	2.2	24
	%	0.5	51.6	14.3	24.5	9.1	100/8.7
Direct Drainages	Sq. Mi.	2.2	1.0	10.3	12.4	10.1	36
	%	6.2	2.8	28.5	34.5	28.0	100/13.1
Total Basin	Sq. Mi.	3.8	15.2	22.9	67.9	165.2	275
	%	1.4	5.5	8.3	24.7	60.1	100/100

TABLE 3: AVERAGE MONTHLY 1979 WASTE LOADS FROM VENETA SEWAGE FACILITIES

MONTH	DISCHARGE	BOD		TOTAL SUSPENDED SOLIDS	
	CFS	mg/l	lbs/day	mg/l	lbs/day
Jan	0.8	12	48	30	120
Feb	0.8	14	56	20	80
Mar	0.8	15	60	12	48
Apr	0.8	14	56	4	16
May	0.8	9	36	4	16
Jun	0.6	10	32	5	16
Jul	0.2	16	13	19	15
Aug	0	-	-	-	-
Sep	0.3	16	26	21	34
Oct	0.3	17	27	24	38
Nov	(0.5)	(16)	38	(25)	60
Dec	(0.6)	(16)	51	(25)	80

( ) - Estimated

crops and orchards. Almost all farms are less than 100 acres. This sub-basin has the least annual rainfall on the average (35-42 inches).

Thirteen percent of the Fern Ridge basin drains directly into the reservoir through small intermittent creeks and groundwater seepage. There are few large ownerships in these drainages, the exception being Corps of Engineers property surrounding the reservoir which includes extensive wetland areas. Some urban density areas in Veneta and Crow are located on direct drainages. About 28 percent is forest land located mostly on the west side of the reservoir. The remainder of direct drainage land is mostly rural residential and agricultural use. There is one meat packing company near Veneta. Wastes primarily are non-point source. The extensive rural developments use individual waste disposal systems and are potentially a significant source of reservoir enrichment. Most of those developments are on flat land or land with less than 12 percent slope. Precipitation ranges from 40 to 50 inches per year.

BASIN EROSION POTENTIAL

The erosion potential in the Fern Ridge Reservoir watershed was analyzed by examination of geology, topography, soils and land use data and erosion studies on similar Coast Range watersheds. The objective was to relate the degree of erodibility to possible sources of sediments and turbidity in Fern Ridge Reservoir.

Geology

The geologic features of Fern Ridge basin are mainly the result of headward cutting of rivers through the soft sedimentary rock, leaving igneous rock capping the high elevations (Baldwin, 1964). This occurred during the Pleistocene ice age when the sea level dropped several hundred feet. Figure 7 depicts the basin geology which includes three bedded sedimentary formations (Tyee, Eugene, and Spencer); one formation of volcanic tuff and agglomerates (Fisher Formation); areas of intrusive material; and areas of braided quarternary alluvium.

The Tyee (or Fluornoy) formation is the oldest material in the area (middle Eocene) and occurs mainly in the upper Long Tom basin and western part of Coyote basin. It consists of rhythmically bedded micaceous sandstone and siltstone. In the Fern Ridge basin, the type of Tyee found has long gentle slopes broken by benches and rounded ridge tops rather than the steeply sloped, sharply dissected type of Tyee found in other parts of the coast range. The Tyee formation is a soft parent rock material which has been extensively weathered and deeply cut by stream activities.

The Spencer formation occurs mainly in the Coyote Creek basin and the small direct drainages to the reservoir. The Spencer formation overlies the Tyee formation. Generally, the Spencer and Tyee formations are quite similar lithologically, and can be expected to weather down similar erosion materials.

The Eugene formation is composed of marine deposits from the mid-Oligocene era. It underlies much of the Amazon Channel drainage and also occurs, to a limited extent, in the Coyote Creek drainage.

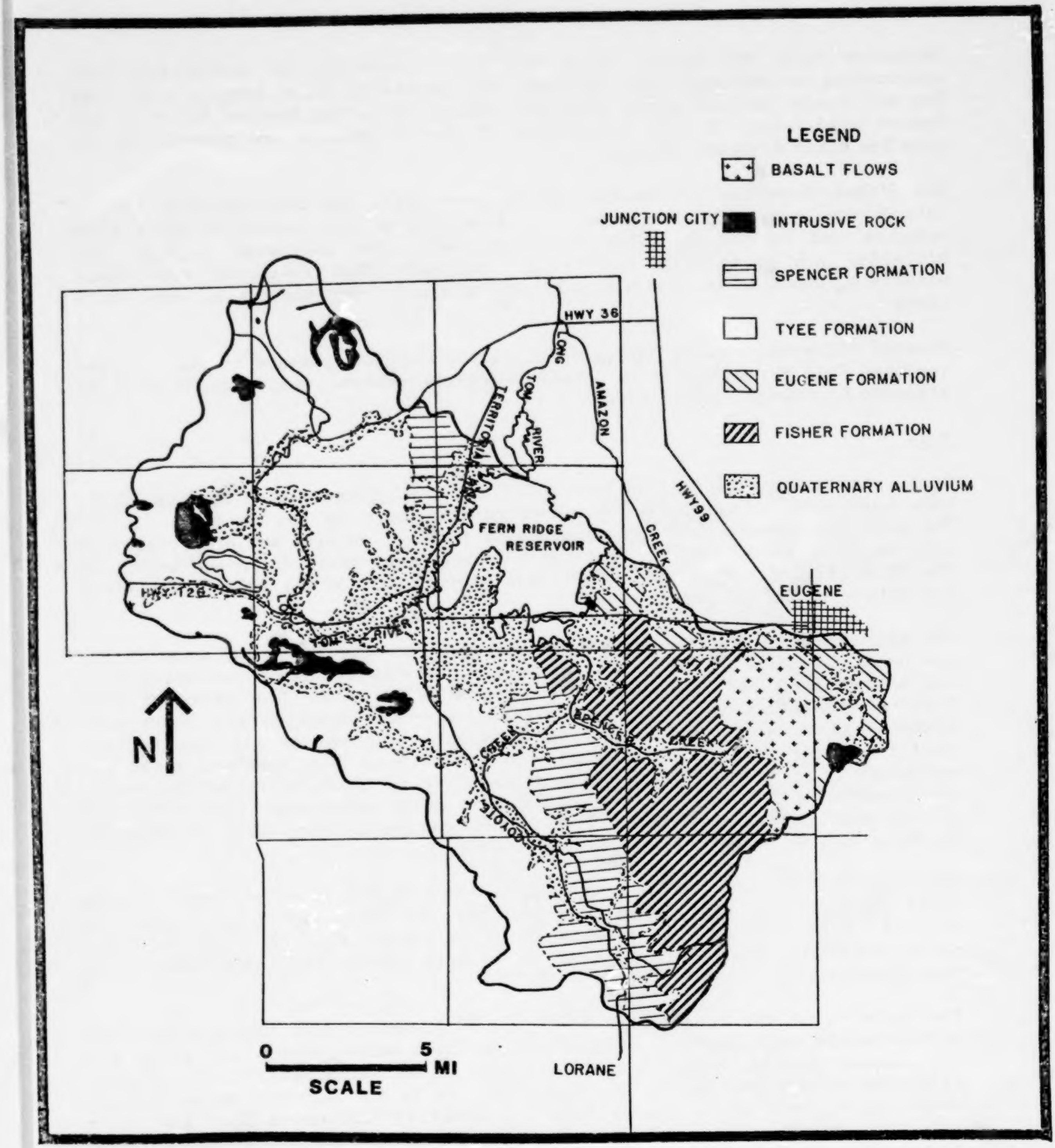
LEGEND
BASALT FLOWS
INTRUSIVE ROCK
SPENCER FORMATION
TYEE FORMATION
EUGENE FORMATION
FISHER FORMATION
QUATERNARY ALLUVIUM
JUNCTION CITY
HWY 36
LONG
TOM
RIVER
AMAZON
TERRITORIAL HWY
HWY 99
CREEK
FERN RIDGE
RESERVOIR
EUGENE
HWY 126
TOM
RIVER
SPENCER
CREEK
COYOTE
CREEK
N
0
5
MI
SCALE
LORANE

FIGURE 7 FERN RIDGE GEOLOGY

SOURCE: USGS SURVEY, COMPLETED BY USING BALDWIN (1964), BEAULIEU (1971) AND VOKES (1955)

Intrusive rock and basalt flows are more resistant to weathering than surrounding sedimentary rock and thus, are generally found capping many Long Tom and Coyote Basin mountain tops and ridges, including Spencer Butte at the Amazon headwaters. A high percentage of the intrusions are present in the Long Tom River drainage (Figure 7).

The Fisher formation is composed of volcanic tuffs and conglomerates. It is late Eocene to early Oligocene. In some places the formation makes bold outcrops and in others, where the finer tuffs have weathered to clay, the hillsides are covered by landslides. The soil that developed from these materials, tends to be unstable and contain significant amounts of expandable clays.

Braided alluvium deposits are found along the dominant streams of the area and surround Fern Ridge Reservoir. Baldwin (1964) reports that 200-300 feet of alluvium is present at Fern Ridge.

Soil

Soil associations, classified by the U.S.D.A. Soil Conservation Service (SCS), have been used to generally characterize the soils in the drainage basins. The soil associations list the predominant soils of an area but do not provide site specific data. Figure 8 locates the eight soil associations occurring in the Fern Ridge drainage basin and Table 4 lists some of the salient stability parameters of the individual soils.

The Natroy-Bashaw, Dayton-Natroy, and Bellpine-Hazelair-Philomath associations are weak and prone to movement. These associations are found exclusively in the Coyote Creek and Amazon channel systems (Figure 8). The types of soil failure characteristic of these associations are deep seated rotational slumps, streambank slumping, and translational slippage of the top horizon when the lower layer soils deform from saturation. The Hazelair soils are particularly prone to slippage. The instability of these soils is the result of significant amounts of montmorillonite clays with hign plasticity and shrink swell potential (Table 4). The montmorillonite clays are, in addition to their erosion potential, highly suspendible in water.

The Waldo-McAlpin association prevalent in the Long Tom River and upper Coyote Creek valleys also exhibits high plasticity and shrink-swell potential but U.S.D.A. Soil Conservation Service (SCS) personnel say the clays in these soils are mostly locked in and tend to be more stable than the other three weak associations.

The majority of the upper Long Tom watershed possesses deep cohesive soil and is moderately well drained. In the Oregon Coast Range, creep and slump are most common on deep, cohesive soils in areas of soft sedimentary rock, notably siltstone of the Tyee formation. Typically, it is the poorly drained terrain which fails, and since the geology and soils of the upper Long Tom basin indicate moderate slope and drainage, they should not be prone to extensive slump and creep activity.

Other critical erosion areas can be expected from the inceptisols of Bohannon-Preacher-Digger and, to a lesser degree, the Peavine-Blachly-Honeygrove associations. The SCS has characterized the

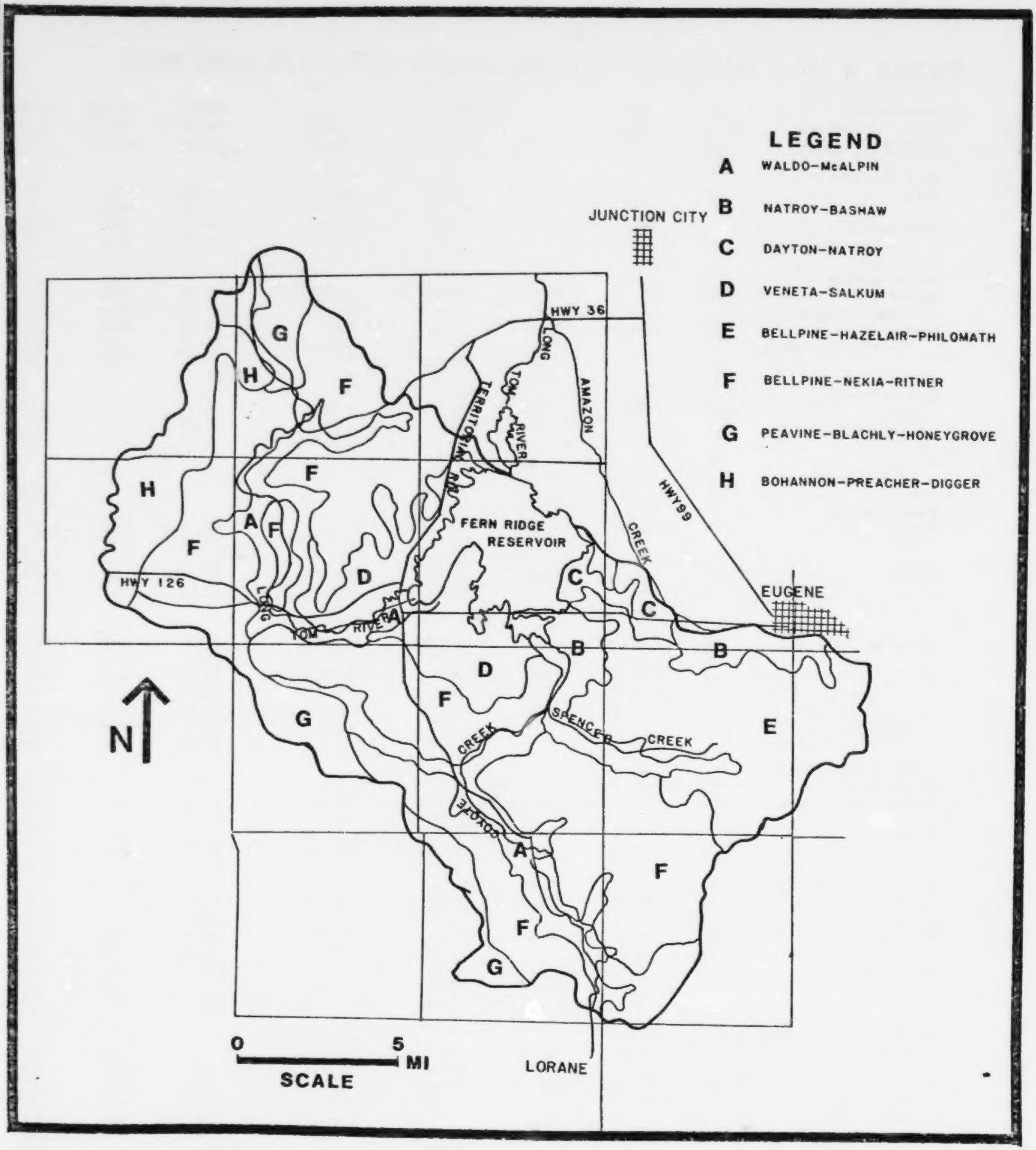
LEGEND
A WALDO-McALPIN
B NATROY-BASHAW
C DAYTON-NATROY
D VENETA-SALKUM
E BELLPINE-HAZELAIR-PHILOMATH
F BELLPINE-NEKIA-RITNER
G PEAVINE-BLACHLY-HONEYGROVE
H BOHANNON-PREACHER-DIGGER
JUNCTION CITY
HWY 36
LONG TOM RIVER
AMAZON
TERRITORIAL RD
HWY 99
CREEK
FERN RIDGE RESERVOIR
EUGENE
HWY 126
LONG TOM RIVER
SPENCER CREEK
COYOTE CREEK
LORANE
N
0
5
MI
SCALE
G
H
F
H
F
A
F
D
A
C
C
B
B
D
F
G
E
A
F
F
G

FIGURE 8 FERN RIDGE SOIL ASSOCIATIONS

SOURCE: LANE COUNTY GENERAL SOILS ASSOCIATION, USDA SOIL CONSERVATION SERVICE. UNPUBLISHED

TABLE 4 SOILS CHARACTERISTICS OF SOIL ASSOCIATIONS IN FERN RIDGE BASIN

Association (Major Soil Name Types)	% of Soil Assoc.	Soil Depth (in.)	Precip.	Depth from Surface	USDA Texture	Plasticity Index	Shrink Swell Poten.	Erosion Factor K
Waldo-McAlpin								
Waldo	45	40-60	40-60	0-10	SiClLo	10-15	mod	NA
				10-60	SiCl-Cl	20-30	high	NA
McAlpin	35	60+	40-60	0-23	SiClLo	10-15	mod	.24
				23-65	SiCl	15-25	high	.28
Natroy-Bashaw								
Natroy (montmorillonite)	50	60+	40-60	0-5	SiClLo-Cl	20-30	high	.20
				5-60	Cl	30-45	high	.20
Bashaw (montmorillonite)	35	60+	40-50	0-60	Cl	40-60	high	NA
				0-15	SiClLo	10-20	mod	NA
				15-60	Cl	40-60	high	NA
Dayton-Natroy								
Dayton (montmorillonite)	40	60+	40-50	0-15	SiLo	5-15	low	.43
				15-40	Cl	25-50	high	.32
				40-72	SiClLo	2-15	mod	.49
Natroy (montmorillonite)	35	(same as above)						
Veneta-Salkum								
Veneta	40	60+	40-50	0-14	Lo-SiLo	NP-10	low	.37
				14-39	ClLo-Cl	5-15	mod	.32
				39-60	Cl	40-50	high	.20
Salkum	35	60+	40-60	0-14	SiClLo	10-15	low	.28
				14-40	SiCl-Cl	15-25	mod	.32
Bellpine-Hazelair-Philomath								
Bellpine	40	20-40	40-60	0-10	SiClLo	15-20	low	.28
				10-26	SiCl-Cl	20-25	mod	.32
Hazelair	30	24-40	40-60	0-18	SiClLo-SiLo	11-20	mod	.32
				18-30	SiCl-Cl	40-50	high	.24
Philomath (montmorillonite)	15	12-20	40-60	0-6	SiCl	30-50	mod	.32
				0-6	CoSiCl	40-50	high	.28
				6-18	Cl or CoCl	40-50	high	.24
Bellpine-Nekia-Ritner								
Bellpine	45	(same as above)						
Nekia	25	20-40	40-60	0-9	SiClLo	11-15	low	.24
				9-36	Cl	5-20	mod	.20
Ritner	15	20-40	40-60	0-15	Co or Gr:SiClLo	11-15	low	.24
				15-40	VCoSiCl	15-25	mod	.20
Peavine-Blachly-Honeygrove								
Peavine	55	20-40	60-80	0-10	SiClLo	10-20	low	.28
				10-36	SiCl	25-45	mod	.28
Blachly	20	40-60	80-120	0-6	SiClLo	15-10	low	.17
				6-60	SiCl	10-20	mod	.37
Honeygrove	15	40-60+	60-80	0-12	Cl	10-15	low	.15
				0-12	SiClLo	5-10	mod	.20
				12-72	Cl	10-15	mod	.20
Bohannon-Preacher-Digger								
Bohannon	40	20-40	60-120	0-11	GrLo-Lo	NP	low	.10
				11-24	GrClLo	NP	low	.17
Preacher	25	40-60	80-120	0-14	ClLo	11-15	mod	.15
				14-42	ClLo	11-15	mod	.17
				42-60	Lo-SaLo	NP	low	.32
Digger	20	20-40	60-80	0-4	GrLo	NP-10	low	.10
				4-18	GrLo	NP-10	low	.20
				18-30	VGrLo-VCoLo	5-10	low	.24

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[1] Percentage does not add up to 100; remaining percentage is composed of minor soil types.

NA - Not Available
NP - Non-plastic

Cl - Clay, Clayey
Si - Silt, Silty
Sa - Sand, Sandy
Lo - Loam
Gr - Gravel, Gravely
Co - Cobble, Cobbly
V - Very

Peavine-Blachly-Honeygrove association as deep and with slopes dominantly less than 45 percent, but with short slopes as steep as 60 percent.

The Bohannon-Preacher-Digger association tends to be steeper mountainous uplands with coarsely textured, shallow soils--particularly the Bohannon and Digger soils. Mass wasting studies in the Oregon Coast Range have concentrated on the steeper type of Tyee terrain occurring in the more westerly mountains of the Siuslaw National Forest. Debris avalanches and debris torrent are the predominant types of soil failure associated with these soils. Ketcheson and Froehlich (1978) found that half of the failures in undisturbed drainages, and 90 percent of the failures in clearcuts, occurred on slopes of 80 percent and greater, and all natural failures occurred on slopes greater than 54 percent. Dipert and Harkenrider (1978) found 79 percent of all inventoried failures to occur on slopes of 80 percent or more. Therefore, steep areas found in the two soil associations are predictably prone to stability problems, particularly related to clearcut activity, but slopes less than 60 percent have a low probability of slope failures even with clearcut.

The only significant steep areas are found in the western portions of the Long Tom River basin--specifically, the headwater sections of Hays, Poodle and January Creeks and the Iron Mountain area. This region also includes a major portion of 35 to 60 percent slope range. The approximate total area of the Fern Ridge basin on slopes greater than 60 percent is 3.5 square miles or 1.5 percent of the basin. Given the limited amount of steep areas, debris avalanche and torrent failures will likely be limited.

Land Use Impacts

Land use activities often lead to accelerated erosion. Forest, agriculture, urban and rural land use distributions were given in Table 2. Land use provides a fair representation of the possible types of erosion impacts which might be experienced in a drainage basin. For example, extensive forest cutting on steep slopes or extensive plowing in clay soils are often associated with major erosion activity.

Clearcutting activities were assessed by contrasting color infrared aerial photographic images of the Fern Ridge drainages . A ten year interval between photos was selected as a fair representation of the time necessary for revegetation and stabilization of clearcut areas. Township centered black and white aerial photographs were also used for reference and as the base maps for plotting recent clearcut activity. Approximately 2.5 ± .5 square miles of timberland have been cut in the last 10 years, of which seven percent, or 150 to 220 acres, occurred on slopes greater than 60 percent, while 32 percent occurred on 35 to 60 percent slopes and 61 percent occurred on 12-35 percent slopes. Little harvested acreage was found upon the more unstable topography. The harvest represents a cutting rate on steep slopes of only approximately 22 acres per year. The analysis of infrared photographs did not identify any major or active slope failure in recent clearcuts. Construction of logging roads is another activity that can lead to soil loss or land slides. Land with a slope greater than 35 percent requires special practices to avoid landslides. Logging road construction was not examined for this study.

The predominant agricultural activities in the three drainage basins are pasturing and seed and grain production. The main concentrations of agricultural land occur in the Coyote Creek drainage, southern direct drainage, and the western portion of the Amazon basin. Agricultural activities generally overlie the weak clay soils of the Natroy-Bashaw, Dayton-Natroy, and Bellpine-Hazelair-Philomath associations. Field tillage related to seed and grain production and the physical disruption of soils associated with pastured livestock present a potential source of erosion of these clay soils. The actual erosion of these soils is likely tempered by the very gentle relief of the agricultural land (virtually all is in the 0-12 percent slope range). Agricultural streambank and riparian zone activities (vegetation removal, livestock watering and machinery usage) could easily expose, erode or entrain the mobile clays in both intermittent and permanent drainages. General streamside stability depends on preserving vegetation and minimizing physical disturbance of banks. Agricultural activity in the intermittent drainages and ditches may also contribute to erosion of clay soils.

Urban development is extensive in the Amazon basin (Table 2). Much of the Amazon basin also contains weak soils. The south hills and Willow Creek areas are dominated by the Bellpine-Hazelair-Philomath associations. A strong potential for erosion and increased suspended sediment associated with construction and land development activities exits there. Rural residential development in the vicinity of Fern Ridge also has the potential of accelerating erosion because of the clay soils.

Conclusion

The Long Tom basin has a comparitively low potential for natural or accelerated erosion due to primarily deep, cohesive and stable soils with moderate to low relief and fairly limited forestry activity. Erosion concern is expected to be limited to a few steep areas with logging activities. Present logging and road construction practice requirements should effectively control the future erosion. In addition, the material that erodes from the streambanks would mostly be coarse and readily settle out. The Long Tom is likely to be the major source of coarse sediment deposited in the reservoir.

The Amazon basin is a marginally erodable area with a large percentage of weak soils. However, much of the clay soils are paved over and only a small amount of area is under construction and exposed. The relatively low flow discharge compared to the Long Tom and Coyote basins also minimizes the clay contribution from Amazon Channel to Fern Ridge.

The Coyote Creek drainage basin has the highest potential for turbidity causing erosional problems. The areas most prone to failures are found in the lower reaches of the Coyote Creek and the Spencer Creek sub-basin as well as the southern direct drainages due to the weak soils and agricultural activities. The montmorillonite clays in the area are particularly susceptible to entrainment in water and can be expected to produce high turbidities. Overall, the turbidity caused by suspended clay in water is expected to be more of a problem than actual volume of suspended and settlable solids deposited in the reservoir.

STREAM FLOW PATTERNS

The Fern Ridge basin streams have flow patterns similar to other rivers originating on the east slope of the Coast Range. Streams respond quickly to precipitation because there is little, if any, snowpack and groundwater aquifers are predominantly shallow and low yield. As a consequence, upper Long Tom basin, which receives the most rainfall and has the deepest soils, produces the most stream flow and has the highest yield. The Coyote Creek basin is next highest both in flow volume and yield per square mile of basin. The small direct reservoir drainages have not been gaged but their yields are probably about the same as Coyote Creek because of the similar geography and precipitation rate. The Amazon basin has an even lower yield in spite of extensive impermeable surface. This is attributable to an even lower precipitation level than Coyote basin.

The Long Tom River and Coyote Creek both have stream gaging records exceeding 50 years. There are only 16 years of record for the Amazon, so statistical evaluations are less reliable. Monthly averages measured at the gaging stations are shown in Figure 9. For Fern Ridge Reservoir, the critical months in terms of water quality impacts during summer are the February through June filling season and the July through September conservation pool season.

The flows in Coyote Creek are normally reduced or fully depleted by irrigation usage from July to September. The water rights on file, totaling 12.9 cfs for irrigation, exceed the natural summer flow. The Water Policy Review Board has withdrawn the creek from further appropriation (except through storage). Irrigation from the upper Long Tom is minimal and there is no record of flow being fully depleted. Amazon Channel flows are augmented during summer by runoff of municipal water from lawn watering and other urban uses, and by channel construction (deepening) which has cut through parts of the clay layer to tap the lower groundwater table. The channel has a diversion structure near Royal Avenue which permits the low flows (levels of less than 15 cfs) and portions of flows more than 900 cfs to spill into the original Amazon Creek channel rather than being diverted into Fern Ridge. However, the low flow culvert easily becomes clogged because of extensive vegetation and litter in the channel and unless there is routine maintenance, all low flow would be diverted to Fern Ridge. During this monitoring effort, summer flows in the Amazon were not diverted to Fern Ridge.

Most land runoff wastes and erosion occur during major winter storms. Spring storms normally fall on saturated soils and a high percentage of the precipitation flows directly into the streams. Infrequent summer storms and early fall storms are largely absorbed by the soil. The Long Tom and Coyote do not reach peak flows until one to three days following peak rainfall, while the Amazon reaches peak flow within five to ten hours. Storm pollutant concentrations are often significantly higher than the base flow conditions so pollutant loading would ideally be based on a separate analysis of storm and base flow input.

Spring and summer storm flows have the most potential to affect the summer water quality in Fern Ridge because much of that runoff remains in the reservoir for the entire conservation season. The volume of individual storms, however, would usually be small compared with reservoir volume.

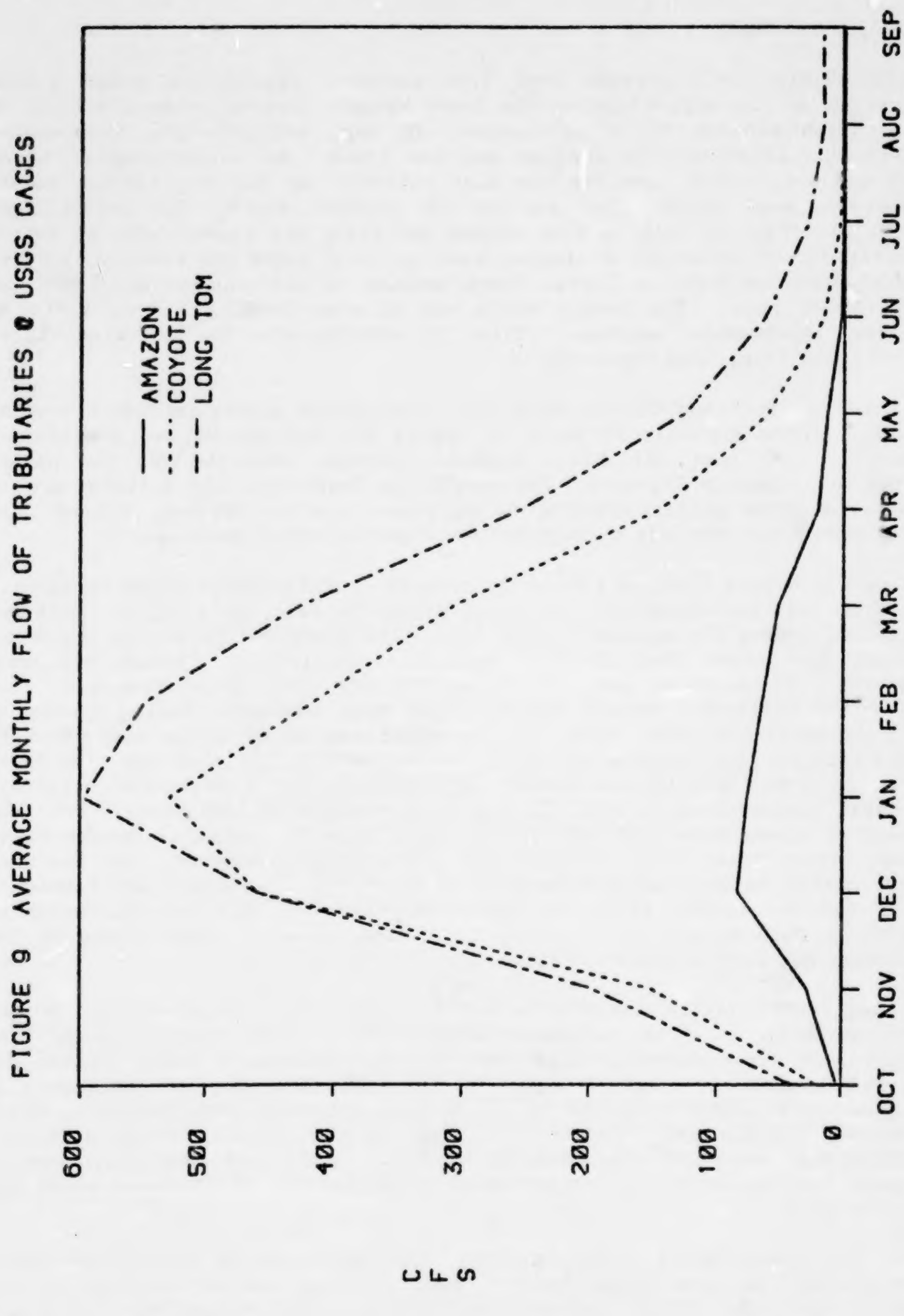

FIGURE 9 AVERAGE MONTHLY FLOW OF TRIBUTARIES @ USGS GAGES

Spring and summer storm impacts would be strongest in the vicinity of tributary inflow. The temporary increases in bacteria, and the cumulative increase in organic, plant nutrients and toxins are a greater potential problem at these times than erosion.

The flow and pollutant load vary greatly from year to year depending on the volume and intensity of the storms. Infrequent major storms can cause massive erosion or slides that effect water quality for long periods. For example, turbidity problems in another upper Willamette reservoir (Hills Creek) were attributed to erosion on a single small tributary during a large flood in December, 1964 (Youngberg, et al. 1971). A few steep unstable areas in the Fern Ridge basin could produce occasional massive loads but, because of the winter drawdown and complete exchange of water, the effects from major events would not persist longer than a single season.

SECTION V. TRIBUTARY MONITORING RESULTS

The mean and median values of the stream monitoring effort are given in Table 5 while the extreme values are given in Table 6. Although compilation of the physical, chemical and biological data is relatively easy, interpretation of quality from the raw data (Appendix C) and statistics is not clear cut. This discussion is divided into sections on chemical parameters, nutrients, oxygen, bacteria, turbidity, residues and metals. Loadings are estimated, where applicable, for the spring filling season and summer conservation season. Nutrient, residue and metals data are compared with standards and other national data. The next section on lake water quality findings includes additional interpretation of the basin input.

CHEMICAL CHARACTERISTICS

All of the tributary waters have low levels of conductance, alkalinity hardness and chloride. The Long Tom River values are lowest and generally Amazon Channel values are highest for those parameters. There were no extreme pH levels measured. Long Tom River and Coyote Creek averaged 6.9 and 7.0 with Amazon Channel at 7.2. The lack of buffering capacity, however, indicates the streams are susceptible to extreme fluctuations from spills. Two recent spills on the Amazon (one acid and one caustic) have resulted in major fish kills in the channel, but low flow conditions appeared to have prevented impacts in Fern Ridge.

The Long Tom River was cooler during the summer than Coyote Creek or Amazon Channel. It did not exceed the 20°C standard for cold water fish during monitoring, but summer sampling was not frequent enough to determine whether the cool temperatures are maintained all summer. The highest temperature recorded in the Amazon was 23°C and in Coyote Creek was 22.5°C. Amazon was normally measured early in the day so maximums would exceed that value.

NUTRIENTS

The Long Tom River normally had the highest nitrite-nitrate nitrogen levels and the lowest total phosphorus and orthophosphorus values of the tributaries. Coyote Creek was lowest in nitrogen and about the same as the Amazon in phosphorus concentrations. None of the average levels exceeded state guidelines (0.1 mg/l phosphorus or 0.3 mg/l nitrogen) but Coyote and Amazon were close for phosphorus and several individual values did exceed guidelines (Table 5).

Comparison of these values with a nationwide non-point source stream nutrient level study (Table 7) shows that nutrients in the Long Tom were significantly higher than the average for forested watersheds indicating the impact of the point source discharges. Coyote had lower nitrogen concentrations but higher total phosphorus and orthophosphorus than drainages with partial forest, partial agricultural or mixed land use basins. The Amazon nitrogen levels were much lower than the national average for urban areas while phosphorus was about the same.

TABLE 5: TRIBUTARY WATER QUALITY STATISTICS - (16 sample dates)

Parameter		AMAZON CHANNEL Mean	AMAZON CHANNEL Median	COYOTE CREEK* Mean	COYOTE CREEK* Median	LONG TOM RIVER Mean	LONG TOM RIVER Median
Flow	cfs	45.1	18.0	421	170	495	280
Temperature	°C	12.8	11.3	12.7	11.3	11.9	11.5
pH	su	7.2	7.2	7.0	7.0	6.9	6.8
Conductance	umho	140	123	100	78	44	38
Alkalinity	mg/l	48.6	42.6	26.4	24.3	13.5	12.5
Hardness	mg/l	54.6	46.6	29.7	28.8	11.9	11.1
Chloride	mg/l	10.4	9.0	9.6	6.8	3.7	3.5
DO	mg/l	8.3	8.6	8.9	9.6	9.5	9.5
BOD	mg/l	4.4	4.3	4.6	4.9	2.7	2.3
COD	mg/l	20.5	19.3	12.1	11.4	8.3	7.8
Transp. secchi	in	16.9	14.2	15.1	16.0	28.8	29
Turbid.	NTU	23.3	24.5	28.1	22.0	9.9	6.9
Total Res.	mg/l	142.2	140.8	107.9	106	62.4	59
Non Fil Res	mg/l	28.9	24.0	29.6	34.5	20.9	22
Nitrogen	mg/l	.145	.141	.080	.070	.195	.170
Ammonia	mg/l	.022	.020	.041	.020	.015	.01(.005)
Phos Total - P	mg/l	.095	.090	.098	.100	.053	.052
Phos-Ortho	mg/l	.039	.040	.036	.041	.019	.012
Tot Coli	#/100ml	1825	1400	3332	2850	350	270
Fecal Coli	#/100ml	638	400	2245	1240	117	80
Iron	mg/l	903	885	1166	1030	814	805
Lead	mg/l	7.4	5.5	14.2	1.0	0.8	1.0

---

* Excludes one sample (9-29-81) with extreme pollutant values which greatly skew results--see Table 5

- Underlined values exceed state standards or guidelines

TABLE 6: WORST WATER QUALITY OF TRIBUTARIES

Parameter	Unit	AMAZON CHANNEL Value	AMAZON CHANNEL Date	COYOTE CREEK Value	COYOTE CREEK Date	LONG TOM RIVER Value	LONG TOM RIVER Date
Temperature	°C	23	6-23	22.5	7-12	20	7-21
Chloride	mg/l	21.8	4-21	219	9-29	5.7	6-23
DO	mg/l	4.2	9-29	0	9-29	7.3	7-21
BOD	mg/l	* 6.9	5-18(8/25-9/29)	8.3*	7-21*	4.8	7-21
COD	mg/l	28.3	8-25	261	9-29	16.0	9-29
Trans. Secchi	inches	7	11-23	8	9-29	17	12-28
Turbidity	NTU	50	2-16	60	2-16	17	2-16
Total Residue	mg/l	230	5-18	768	9-29	85	11-23
Non-Fil. Res.	mg/l	106	5-18	70	5-18	51	5-18
Settlable Res.	mg/l	0.04	2-16	0.04	3- 2	0.05	11-23
Nitrate Nitrite-N	mg/l	0.41	11-23	0.16	11-23	0.47	11-23
Ammonia	mg/l	0.06	3-15	4.0	9-29	0.13	9-29
Phosphorus Tot-P	mg/l	0.157	2-16	3.11	9-29	0.111	9-29
OrthophosPhorus	mg/l	0.066	11-23	1.94	9-29	0.089	9-29
Total Coliform	#/100ml	*4000	8-25	200,000	9-29	1080	5-18
Fecal Coliform	#/100m	4000	8-25	100,000	9-29	480	9-29
Iron	ug/l	1950	11-23	2,290	9-29/11-23	1270	8-25
Lead	ug/l	26	2-16	120	11-23	2	1-25

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* BOD for 9-29 impossible due to zero oxygen

- Underlined values exceed state standards or guidelines

TABLE 7: AVERAGE NATIONAL NUTRIENT LEVELS RUNOFF FROM FOR VARIOUS LAND USE DISTRIBUTIONS[1]

Land Use Class	Inorganic Nitrogen mg/l	Total Phosphorus mg/l	Ortho Phosphorus mg/l
75-80% Forest	.128	.024	.012
50-75% Forest	.294	.034	.014
50-75% Agriculture	.945	.085	.037
Mixed	.545	.049	.021
> 40% Urban	1.189	.092	.043

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[1] Omernik 1977

Eight samplings occurred during the 1981 and 1982 filling seasons. Most of the spring samples included some level of surface runoff from storms. No composite storm samples were collected, but extreme nutrient concentrations were not greater than twice the mean or less than half of the mean. Table 8 compares the tributary inflow of nutrients, the reservoir nutrient pool and nutrient outflow during the 1982 filling season. This table is discussed in terms of a gross nutrient budget in the next section. In general, if algae problems occur in Fern Ridge, the Long Tom should be considered the major source of nitrogen and Coyote Creek the major source of phosphorus.

OXYGEN AND BACTERIA

The organic influx to the reservoir was normally low to moderate. The ultimate BOD was measured and averaged 2.2 mg/l in the Long Tom while Coyote and Amazon loads averaged more than 4 mg/l approaching the EPA guidelines of 5 mg/l for protecting aquatic life. On several occasions levels exceeded 5 mg/l in both Amazon and Coyote.

The first heavy rains of fall occurred before the reservoir was drawn down. The runoff was concentrated in the backwater portions of the river channels resulting in some of the highest oxygen demands and lowest dissolved oxygen levels recorded (Table 6). Coyote Creek turned septic from the runoff with no oxygen, and extreme levels of nearly every parameter. The odor of ammonia was strong and small fish crowded the surface for air. Bacteria levels were estimated to be 200,000 per 100 ml. Levels on Amazon Channel and Long Tom River were not as severe following this storm. Upstream samples on Spencer Creek and Coyote Creek indicated the problem source was chiefly located between sampling stations in the lower basin. Field investigation by the State Soil and Water Conservation Division (SWCD) revealed a recently expanded dairy with inadequate lagoon capacity.

Bacteria problems were measured in Coyote Creek at every monitoring time except two summer samples when the flow was 3 cfs and zero. Amazon Channel also commonly had high levels of coliform bacteria, but fecal coliform was not as high as on Coyote Creek. The high bacteria levels indicate a health risk for contact recreation at those two sites. Occasionally, somewhat elevated bacteria levels were detected on Long Tom River also, but not to the extent of the other two.

TURBIDITY AND RESIDUES

As expected from erosion potential and soils inventories, Amazon Channel and Coyote Creek contributed turbid water with high total and suspended solid loads. Turbidity exceeded 25 NTU which is used as a guideline for controlling erosion creating activities. Average residue levels approached or exceeded state guidelines of 100 mg/l for total solids (residues) and 25 mg/l for suspended solids (non-filterable residue). These guidelines were met on the Long Tom River except for two samples where suspended solids exceeded 25 mg/l. The solids and turbidity were highest during storm runoff conditions regardless of the size of the storm. Amazon Channel had the highest level of solids, which, along with higher conductance, metals and COD values, indicate greater levels of organics and exotic material from urban runoff while Coyote

TABLE 8: ESTIMATED NUTRIENT LOADING DURING SAMPLING OF THE 1982 FILLING SEASON*

SAMPLE Date	INFLOW kg/day Amazon	Coyote	Long Tom	Total	OUTFLOW kg/day Long Tom	Reservoir Load (kg) Fern Ridge
A. Nitrite-Nitrate Nitrogen						
2-16	81.2	315.6	691.2	1088.0	1137.8	9082
3-02	29.4	145.3	334.7	509.4	352.3	9502
3-16	6.0	37.4	114.6	158.0	53.8	6713
4-05	19.7	146.8	393.9	560.4	22.5	5985
4-20	3.7	39.6	154.2	197.5	71.4	7861
B. Ammonia - Nitrogen (ND=Not detected)						
2-16	9.8	ND	ND	9.8	ND	ND
3-02	7.8	48.5	ND	56.3	ND	ND
3-16	2.8	37.4	ND	40.2	ND	ND
4-05	3.4	44.0	ND	47.4	ND	ND
4-20	0.7	ND	ND	0.7	ND	ND
C. Total Phosphorus						
2-16	76.8	410.3	185.3	672.4	842.0	4144
3-02	21.2	240.6	68.7	330.5	129.9	4140
3-16	3.6	75.5	27.3	106.4	36.6	5119
4-05	8.3	159.3	75.4	243.0	110.3	5147
4-20	2.2	49.5	40.7	92.4	80.4	7377
D. Ortho-Phosphorus						
2-16	31.3	138.9	44.2	214.4	204.8	1135
3-02	9.1	87.2	17.6	113.9	17.6	1222
3-16	1.8	31.5	10.6	43.9	3.2	923
4-05	3.0	52.9	18.8	74.7	11.2	479
4-20	0.9	18.5	8.8	28.2	12.5	1088

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* Load (kg/day) = 2.447 X Flow (cfs) X concentration (mg/l)

Creek solids probably contain higher levels of clay and silt. Spring samples generally contained higher than average turbidity and solids. Inflow and outflow comparisons are discussed in the following section.

METALS

Only three metals; aresenic, lead and iron; were analyzed during this study. Arsenic, which is known to occur in basin groundwaters, was analyzed to 10 ug/l but was not detected in any stream or lake sample. Each stream has high background level of iron (.4-.8 mg/l). Storm runoff resulted in considerable elevation of iron concentration especially in Amazon and Coyote Creek which had maximum concentrations of 2.0 and 2.3 mg/l respectively. The Long Tom iron maximum was 1.3 mg/l. Lead was not a problem in the Long Tom River. Coyote Creek experienced one extreme lead level of 120 mg/l which may have resulted from a spill or illegal dumping. There was a chronic low level of lead contributed through the Amazon (Table 5). The major source is most likely road runoff containing residue from leaded gasoline. The metal concentrations were not different enough to provide a method of tracing the tributary sources within the reservoir.

SECTION VI: WATER QUALITY WITHIN THE RESERVOIR

There are no known point sources of pollution discharging directly into Fern Ridge. Water quality in the reservoir is the result of tributary and ground water contributions, biological activity, sediment content, human use and physical circulation within the reservoir. This section examines the water quality conditions found in the reservoir and the results of special surveys which attribute problem conditions to their probable sources.

OVERVIEW OF SEASONAL FINDINGS

During winter, Fern Ridge is unsuitable for recreation not only on the basis of reduced access but also due to poor water quality. All parameters except dissolved oxygen experienced their worst values during the flood control season. Bacteria levels consistently exceeded state standards for contact recreation and turbidity values were extreme.

Outflow measurements for quality were only taken once during winter. A comparison with reservoir water quality showed essentially the same values in the pool as in the outflow. This is a reflection of the rapid turnover of stored water during winter.

Several intense storms occurred between February and mid April, 1982. Water quality measurements in that year probably represent severe runoff conditions for spring filling. The spring 1981 samplings occurred during more normal spring runoff conditions. The seasonal average over both years provides a reasonably balanced level for mean and extreme values.

Storm runoff in early February, 1982 (the beginning of the filling season) exhibited water quality similar to other winter monitoring samples, and the outflow values were comparable to reservoir conditions. Other filling season sampling dates showed that nutrient and bacteria levels in the reservoir were different on the east and west side of the pool or dam, reflecting the values of incoming Long Tom water on the west and Coyote and Amazon water on the east. As the reservoir filled and turnover time increased, the pool values reflected a mixed condition with levels intermediate between those measured in the Long Tom Bay and Coyote Bay areas. In general, the water quality gradually shifted from winter extremes to improved summer levels during the filling season. The shift was related to the onset of growth of aquatic vegetation, the increase in storage and detention, which allowed residues to begin settling, and the decrease in tributary inflow. As the reservoir filled, there was a marked difference between water quality at the "Bay" sampling stations. Details of those differences follow.

The water quality during summer was good for all parameters except those measuring clarity (turbidity, transparency and residues). Chemical and biological analysis indicated the reservoir could be classified mesotrophic. Turbidity was associated with suspended silt, clay and organics. The pattern was to find the clearest water in early summer and more turbid water in later summer. That indicated the suspended material from tributary inflow during filling settles rapidly and the turbidity measured later orignated from sources within the reservoir. The shallow south and eastern regions were consistently the most turbid.

FLUSHING AND MIXING

The operation schedule for Fern Ridge assures that each year the reservoir stores a new body of water. There is a complete flow through of water several times during winter as flood waters flush the system. The total storage capacity of Fern Ridge is about 25 percent of the average yearly volume of water flowing into the reservoir, therefore, even if the reservoir were kept at full pool, a good turnover of water would be expected each year.

Figure 10 depicts the mean monthly reservoir storage and the Corps of Engineers regulating schedule. The early summer schedule represents the maximum conservation pool storage, while November through January show the minimum pool storage. The drop shown in the summer represents the amount of storage committed to minimum flow releases. If inflow water were available, storage would be permitted to remain at the maximum.

Table 9 provides a water budget for Fern Ridge. Average monthly inflow was extrapolated from the river gage records to cover yield from the ungaged portion of the basin. Outflow was available directly from the Long Tom gaging station below the dam. Water is also lost from the reservoir through evaporation, transpiration of wetland plants and groundwater recharge. The Corps has maintained a daily record of pan-evaporation at Fern Ridge. This rate, when factored by normal reductions for deeper water and applied to the monthly average surface area of the reservoir, yields a reasonable monthly estimate of evaporation. Evaporation losses can equal or exceed surface outflow during summer. The groundwater and transpiration losses were not measured but may grossly approximated as the difference between inflow, outflow and evaporation (16,200 acre-feet per year). This estimate is crude because the difference includes the sum of all errors in the other measurements as well as actual ground water and transpiration losses.

Based on these figures the summer inflow (June-September) typically replaces about 11 percent of the reservoir conservation storage but 31 percent of the storage is lost through outflow and evaporation. The 20 percent net losses in volume result in a 14 percent reduction in reservoir surface area over summer. Most of the exposed area supports extensive wetlands. The adjacent flooded areas become shallower and more subject to wave action.

No areas of the reservoir are isolated from lakewide circulation but Jeans Peninsula does separate the Long Tom Bay from the other shallow area of the reservoir. The Corps of Engineers estimated only 5 percent of the reservoir bottom is sloped greater than 5 percent, while 65 percent is very flat (less than 2 percent grade). The entire south and east sides are both flat and shallow.

As a result of the reservoir's shallow, flat and open configuration the water remains well mixed (from top to bottom) throughout the year. Field and laboratory analysis of water samples from the reservoir never revealed a thermocline. Top to bottom differences were generally slight and gradual. Even chlorophyll-a concentrations were similar at depths of two and twenty feet. Spatial differences in turbidity did exist from bay to bay with Long Tom Bay being the clearest.

FIGURE 10 REGULATION AND AVERAGE STORAGE IN FERN RIDGE

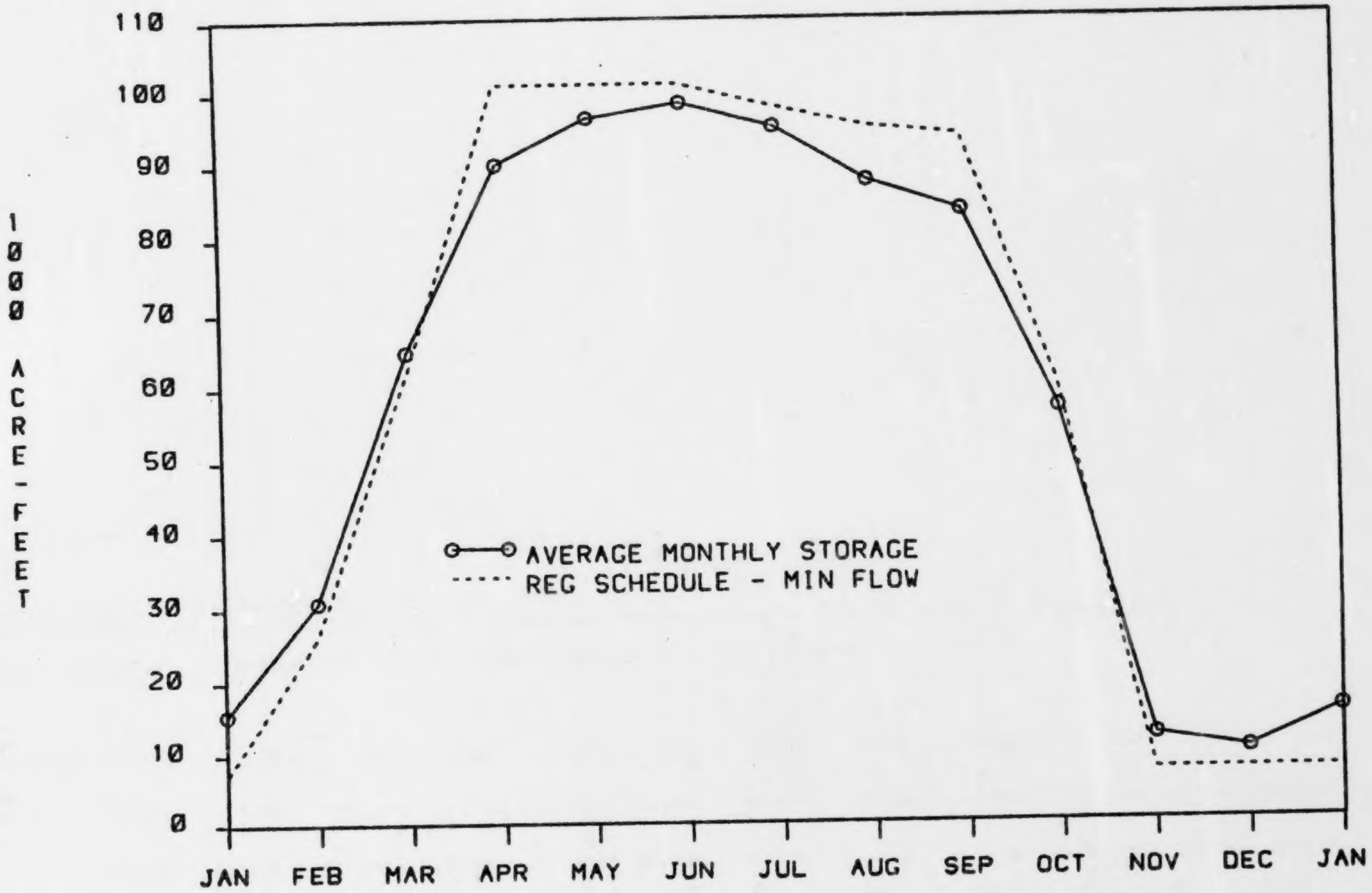

TABLE 9: AVERAGE MONTHLY INFLOW, OUTFLOW AND EVAPORATION

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
INFLOW* AC-FT/Mo	95,170	73,789	61,442	31,740	31,740	6,120	2,542	992	1,440	5,208	28,680	79,236
OUTFLOW AC-FT/Mo	70,768	42,827	24,056	13,920	6,572	3,000	2,976	3,658	6,900	48,050	41,040	81,220
EVAPORATION** AC-FT/Mo	133	150	700	1,640	2,925	3,603	4,598	3,712	2,533	725	86	75

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* INFLOW = Averages from Amazon Gage + 1.4 X Coyote Gage = 1.2 X Long Tom Gage.

**EVAPORATION Rate from 17 yr. monthly average of National Weather Service Figures times 0.73 (correction constant) times average monthly surface area.

CHEMICAL CHARACTERISTICS

The water of Fern Ridge itself tends to be neutral with low conductance, alkalinity, hardness and chloride values (Table 10). The lack of free ions reduces the ability of the system to settle out clay particles. Values of these constituents were slightly greater at the south and east monitoring stations than those in Long Tom Bay and the pool, but much lower than conductance, alkalinity, hardness and chloride measured in Amazon Channel and Coyote Creek. The difference between tributary and reservoir values show the effect of settling and biological activity in the reservoir setting.

WATER CLARITY

The clarity of Fern Ridge water changed considerably from [illegible] monitoring period to the next. Several spatial differences remai[illegible] consistent throughout the year of sampling. During summer turbidity range[illegible] from 2.9 to 18 NTU. It reached 75 NTU during winter. Coyote Bay and Amazon Bay and the bottom sample from the deep pool generally had higher turbidity while Long Tom Bay and the pool surface readings were lower. Perkins Bay shifted from early summer readings midway between upper and lower values to late summer high readings similar to those found in Coyote and Amazon Bays. Table 10 lists the average seasonal levels of parameters related to clarity. Total residues and secchi disc transparencies followed the same pattern as turbidity.

Secchi disc transparency is a measure that is most easily understood by reservoir users. It registers the depth at which objects (the secchi disc) can no longer be seen from the surface. It approximates the depth at which the light intensity is reduced to 15 percent of that near the surface. When clay is not present in the water it can be used to estimate phytoplankton density. In Fern Ridge clay is a major component of turbidity and the transparency is affected by both inorganic minerals and organic matter.

The transparency at the pool in Fern Ridge ranged from 4 inches (winter) to 79 inches, however, the deepest reading in Coyote Bay was 31 inches and in Amazon Bay was 37 inches. During the summer, the lowest transparencies in the shallow monitoring stations (FR-AB, FR-CB and FR-PB) were one foot or less while the lowest readings for Long Tom Bay and the pool were two feet. The relative clarity of Long Tom Bay appeared related to the clarity of inflow from the Long Tom River, greater average depth compared with other bays, vegetated and sandy shores lacking major erosion problems. It may also relate to the northeast orientation of the bay which is perpendicular or oblique to the predominant winds, limiting maximum wave heights.

Secchi disc values less four feet are objectionable for water contact recreation from both an aesthetic and safety standpoint. The Perkins Peninsula Park beach contains broken glass, trash and large rock rubble that cannot be seen from the surface. There are no quantitative state standards for maintaining visibility for recreational use, but a level of four or five feet is the normal maximum depth at which swimmers will use the bottom.

TABLE 10: MEAN SEASONAL TURBIDITY, RESIDUES & RELATED FACTORS - FERN RIDGE RESERVOIR

STATION	pH cu	Conductance umho	Transparancy Secchi-in	Turbidity NTU	Total Res. mg/l	Non-Filterable Res. mg/l	Alkalinity mg/l
SPRING FILLING SEASON (Feb.-May)							
Amazon Bay	6.8	57	23	18.0	84	34	18
Coyote Bay	6.8	53	21	18.3	83	36	17
Perkins Bay	6.8	51	28	16.9	82	31	16
Long Tom Bay	6.8	44	36	9.3	58	22	14
Pool Surface	6.8	49	28	16.2	68	22	15
Pool Bottom	6.9	48	NA	19.6	75	29	15
SUMMER CONSERVATION SEASON (Jun-Sep)							
Amazon Bay	7.2	67	25	9.7	57	15	21
Coyote Bay	7.2	68	22	12.0	62	15	21
Perkins Bay	7.2	67	27	10.0	59	14	21
Long Tom Bay	7.2	66	39	6.2	53	8	21
Pool Surface	7.2	65	46	5.2	49	5	21
Pool Bottom	7.1	66	NA	6.9	57	11	21
FALL/WINTER FLOOD CONTROL SEASON (Oct-Jan)							
Pool Surface	7.0	53	16	38.4	106	33	16
Pool Bottom	7.1	57	NA	40.7	106	32	17

NA - Not Applicable

SUSPENDED SOLIDS

In August 1981, large volume samples of turbid reservoir water were collected from each monitoring station and analysed for solids. Harward (Appendix D) identified the clay minerals present and approximated the particle size distribution of minerals and organics. Material with effective dimensions greater than 50 um was seived from samples, dried and weighed. That size range includes most of the phytoplankton. The solids were concentrated by freeze drying and evaporation. Only one tenth of the weight required for reliable particle size analysis was available, so significant errors could be expected. It particularly appeared that the clay fraction may have been underestimated. The clay fraction (2 um) ranged from concentrations of 1 to 3 mg/l according to Harward's measurements, while the standard laboratory measurement of dissolved solids (0.5 um) from those samples averaged about 50 mg/l. Harward had not expected to find the low proportions of fine silt and clay shown in his data. They may be partly due to problems induced by use of coagulents and dispersants.

The relatively high level (by weight) of the "silt" and "fine sand" are size fractions that would normally settle rapidly. The presence of such material indicates an organic component or on going forces that result in suspension of additional native bottom sediments or resuspension of material deposited by the tributaries. Variability in turbidity during summer is likely due to the resuspension and settling (or partial setting) of larger solids (many of which may have odd shapes that slow down the theoretical settling rate) while the clearest conditions represents the "background" of fine clays, amorphous gels and organic debris that remain in colloidal suspension nearly indefinitely. This is evidenced by very low levels of the larger non-filterable residue measured at the surface of the deep pool on days with greatest transparency. Dissolved solids concentrations were relatively constant throughout the reservoir on any given sampling day, and averaged 45 mg/l over the summer (from Table 10).

Harward also completed x-ray diffraction analysis of the clay fraction of the water samples (2 um). Seven categories of clay minerals were identified (Table 11). An examination of the Coyote Bay and Pool samples with a transmission electron microscope revealed an abundance of diatomaceous or opaline and organic material many of which were less than 0.5 um in dimension. In addition, Harward sited the predominant minerals present as amorphous gels with smectite and disordered kaolinite. Smectite, amorphous components and organic materials would contribute to reservoir turbidity and tend to remain in suspension at low salt concentrations. Normally the other constituents identified (mica, vermiculite and chloritic intergrades) would not remain in suspension long because of their electro-chemical characteristics and larger size, but Harward noted that much more is known about the behavior of those minerals in "pure" water systems than in the complex chemical mixes of natural surface water. Additional analysis of the size distribution of solids and clay minerals versus organic material load would assist in interpreting Harward's findings.

Attempts to examine the daily effect of wind waves in resuspending bottom materials were only partly successful. A transect was set up from Coyote Bay (Figure 11). However, on the first sample date, September 3, 1981, no waves

TABLE 11: CLAYS IDENTIFIED BY X-RAY DIFFRACTION

Clay Minerals	FR-PO	FR-LB	FR-PB	FR-CB	FR-AB
Long Spacing (interstratifed components)	X	X	X	X	X
Smectite	X	X	X	X	X
Vermiculite	X	X	X	?	?
Chloritic integrates - (Smectite and vermiculite)	X	X	X	X	X
Mica	X	X	X	X	X
Kaolin	X	X	X	X	X
Amorphous	X	X	X	?	X

X = verified occurrence
? = probable occurrence

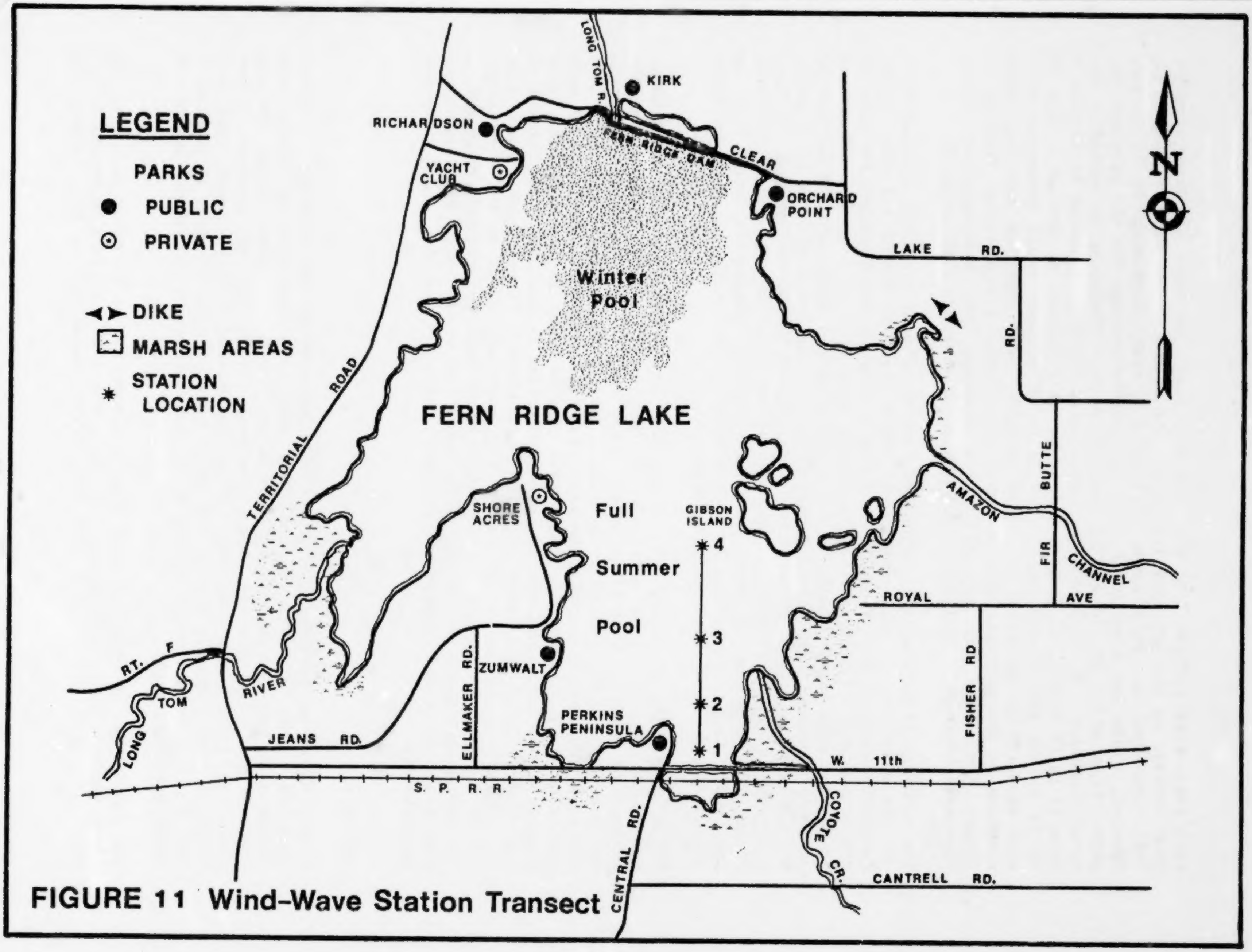

LEGEND
PARKS
● PUBLIC
⊙ PRIVATE
◀▶ DIKE
MARSH AREAS
* STATION LOCATION
N
FERN RIDGE LAKE
Winter Pool
Full Summer Pool
LONG TOM R.
KIRK
RICHARDSON
YACHT CLUB
FERN RIDGE DAM
CLEAR
ORCHARD POINT
LAKE RD.
RD.
BUTTE
FIR
AMAZON
CHANNEL
ROYAL
AVE
FISHER RD
W. 11th
S. P. R. R.
CANTRELL RD.
CENTRAL RD.
COYOTE CR.
GIBSON ISLAND
4
3
2
1
PERKINS PENINSULA
ZUMWALT
ELLMAKER RD.
SHORE ACRES
JEANS RD.
TERRITORIAL ROAD
RT. F
RIVER
LONG TOM

FIGURE 11 Wind-Wave Station Transect

were registered between 7:00 a.m. and 6:00 p.m. The wind had been stronger than average on the previous two days. The second sample date, September 14, 1981, resulted in small waves (0.1 to 0.3 feet) beginning at 11:30 a.m. However, winds had been lower than the monthly average for the previous two days. Figures 12, 13, 14 and 15 show the daily differences in turbidity and total residues. On September 3, secchi disc readings improved at Station 1 from 12 to 15 inches, at Station 2 from 14 to 18 inches, at Station 3 from 13 to 18 inches and at station 4 from 17 to 24 inches. Small reductions were also measured in turbidity and total residue. That apparent settling lends credence to the particle size analysis that showed a significant fraction of larger particles. The relatively low plankton and chlorophyll-a levels discussed later point to the sediment as a major source of that material.

The sampling on September 14 coincided with the date of greatest concentration of chlorophyll-a. Residue measurement began high, decreased and rose again. Turbidity dropped over the day at Stations 1 and 2 and remained the same at Stations 3 and 4 (which was substantially lower than at 1 or 2). There was no strong relationship between the slight wind and waves and the changes in residues measured. The higher levels of residue in early morning at Stations 1 or 2 were suggestive of nightly disturbance of the bottom by fish. Neither wind-wave action nor boating were likely to have caused much disturbance during the previous 12 hours, but the plankton population could also be involved. Carp, in particular, have been linked with turbid conditions elsewhere and are abundant in Fern Ridge.

It is difficult to compute the theoretical relationship between water waves and suspension of bottom material. Yousef, et at. (1978) investigated the effects of boating in shallow lakes. They found that both motor horsepower and boat wave amplitude had an increasing ability to scour sediment, but that cohesive clays would be among the most resistant sediments. Maximum wind wave impact on the bottom of Fern Ridge would tend to occur at the Coyote Bay site because north winds predominate and that station is shallowest and subject to the maximum fetch for north and northwest winds. Strong south winds also occasionally occur and could create high amplitude waves in the deep water, but it is doubtful whether the resultant water velocity at the bottom (20 to 25 feet deep) would be sufficient to scour the silts. Fern Ridge residents have attested to the relationship between wind waves and short term increases in turbidity.

SEDIMENT

Winter drawdown provided an opportunity to examine the reservoir sediment directly. Most of the areas shallower than five feet deep in summer were surveyed by foot, as were some of the deeper (lower elevation) areas. Perkins Bay and the east side of Jeans Peninsula could not be surveyed before reservoir filling and the area had to be omitted from analysis. The soil color, texture, organic content and other visual characteristics were noted in the field. Samples were collected at representative locations around the reservoir (Figure 16).

The Coyote Bay to Gibson Island area was examined in November prior to the first major storm. A large part of that area was a uniform appearing native clay--blue-gray and mottled with iron stains below one to four inches--and

FIGURE 12 DAILY CHANGE IN TURBIDITY, SEPT. 3, 1981
(Wind-Wave Study-Calm Day)

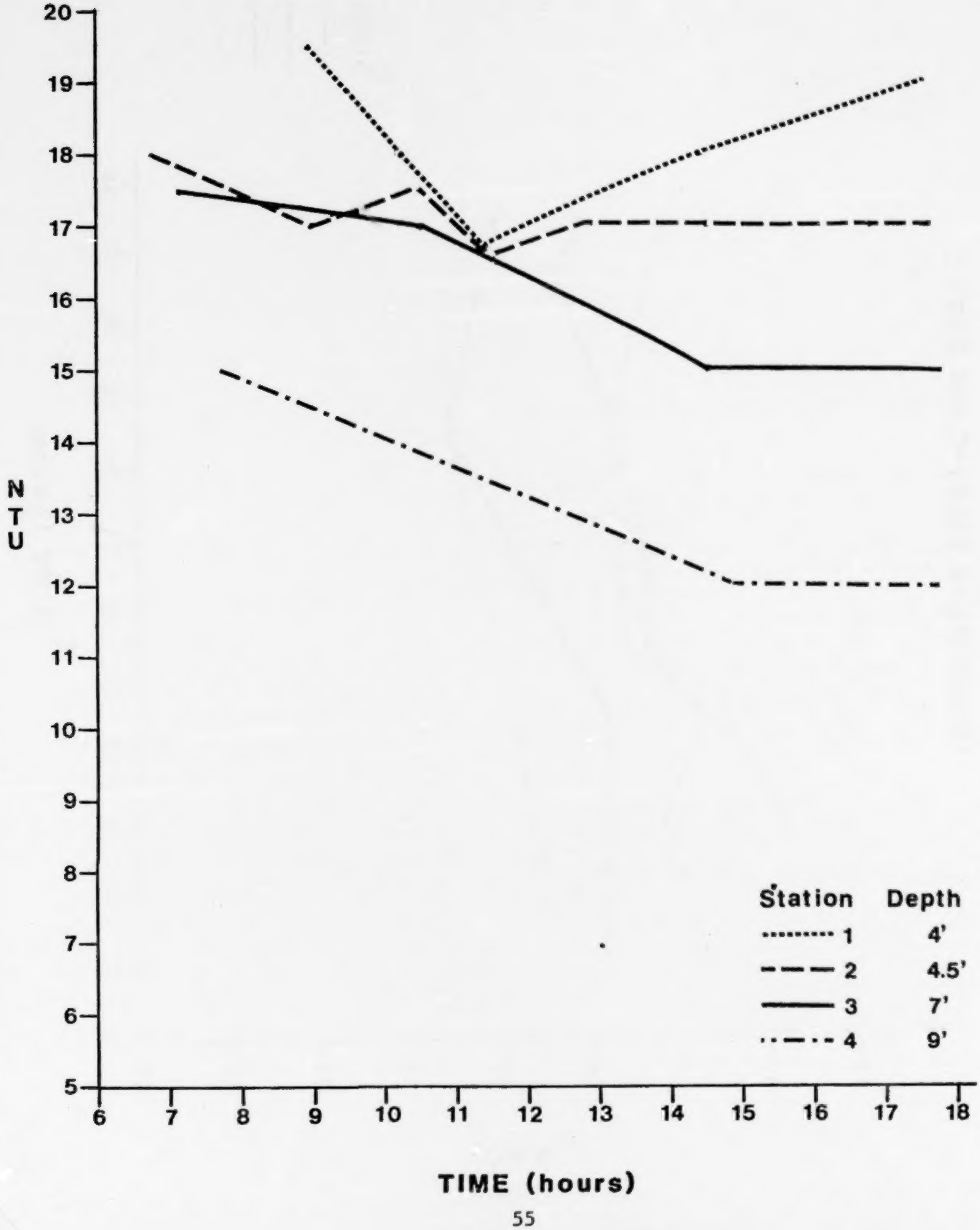


FIGURE 13 DAILY CHANGE IN TOTAL RESIDUE, SEPT. 3, 1981
(Wind-Wave Study-Calm Day)

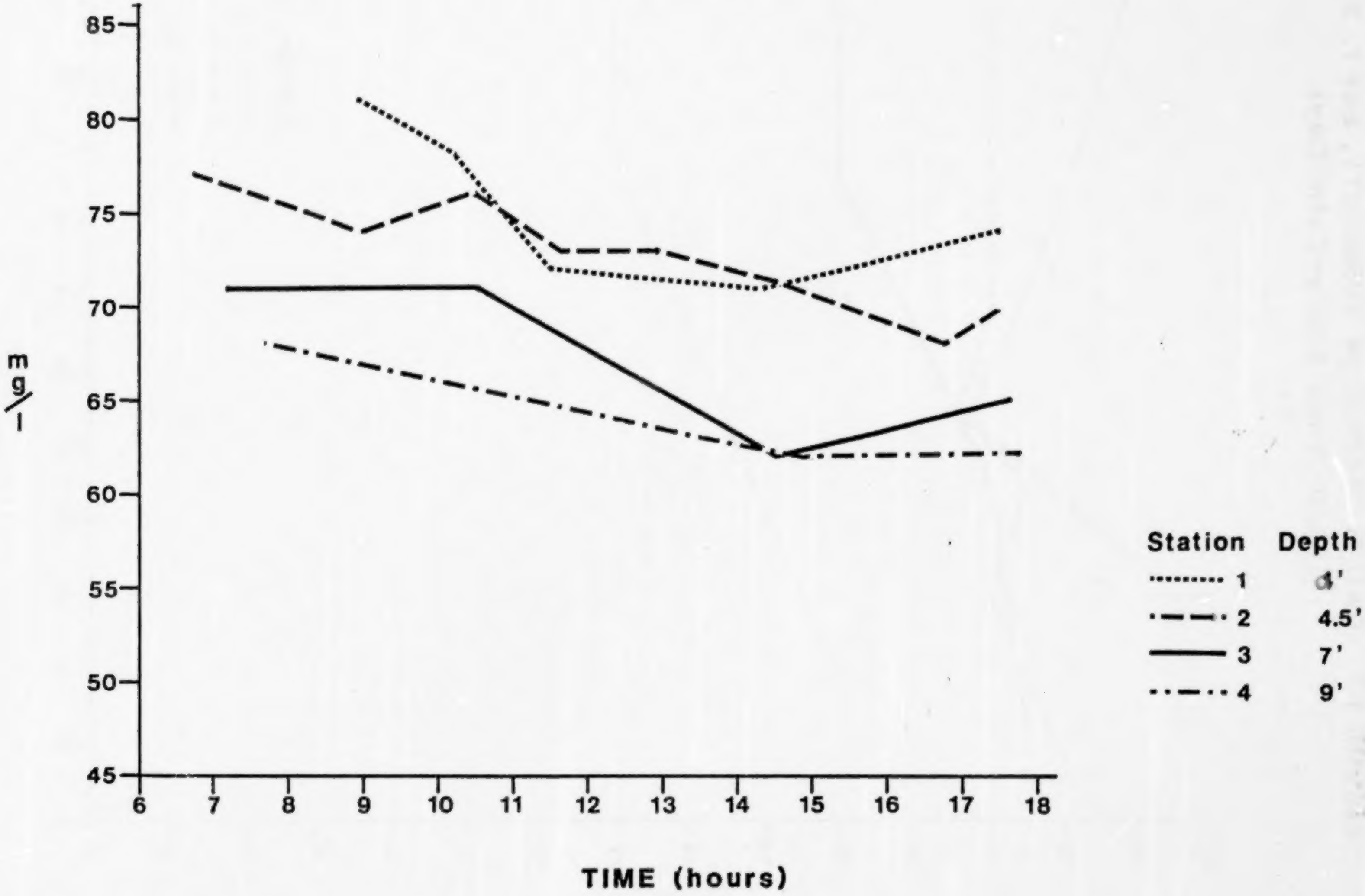


FIGURE 14 DAILY CHANGE IN TURBIDITY, SEPT. 14, 1981
(Wind-Wave Study-Gentle Wind)

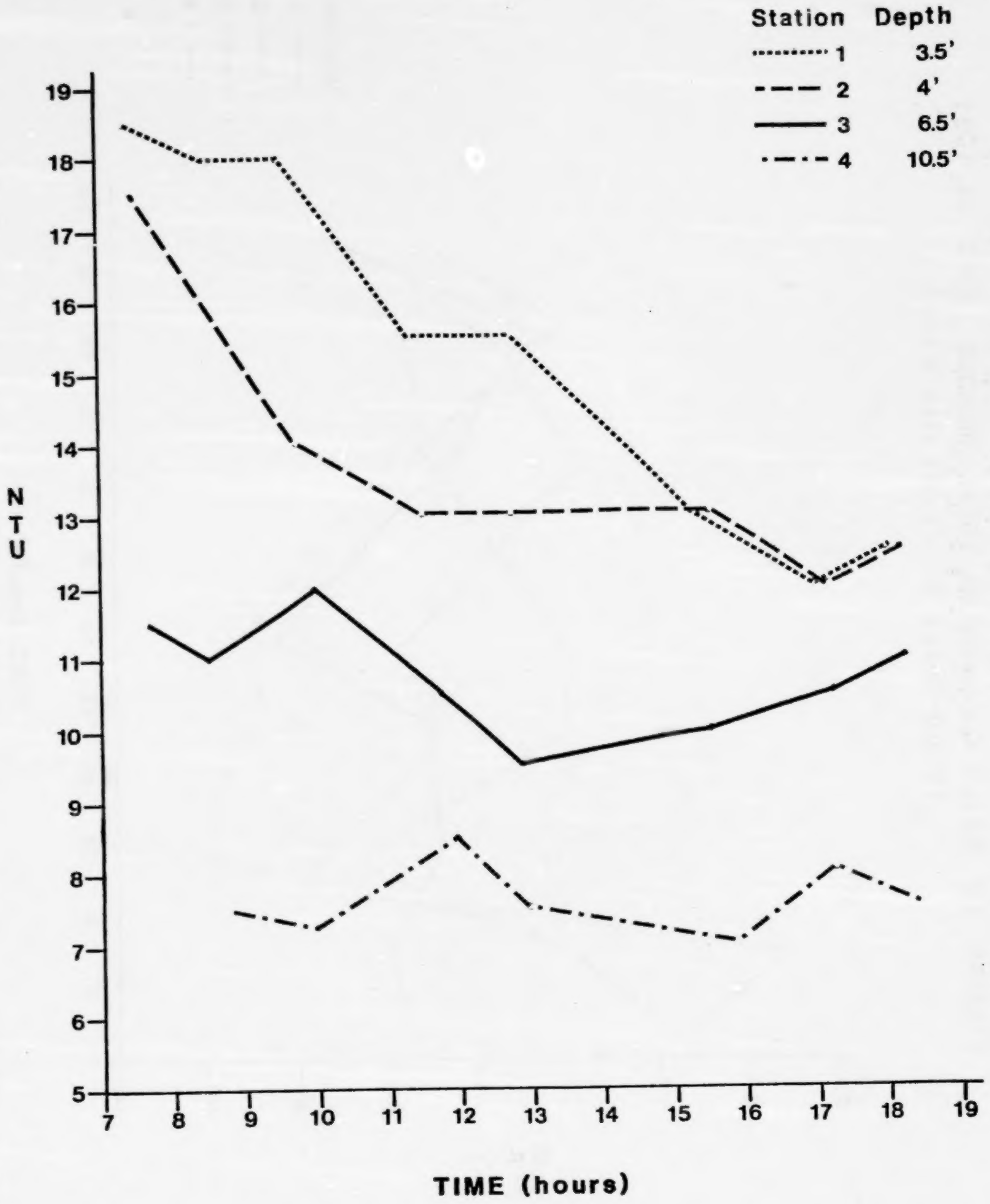
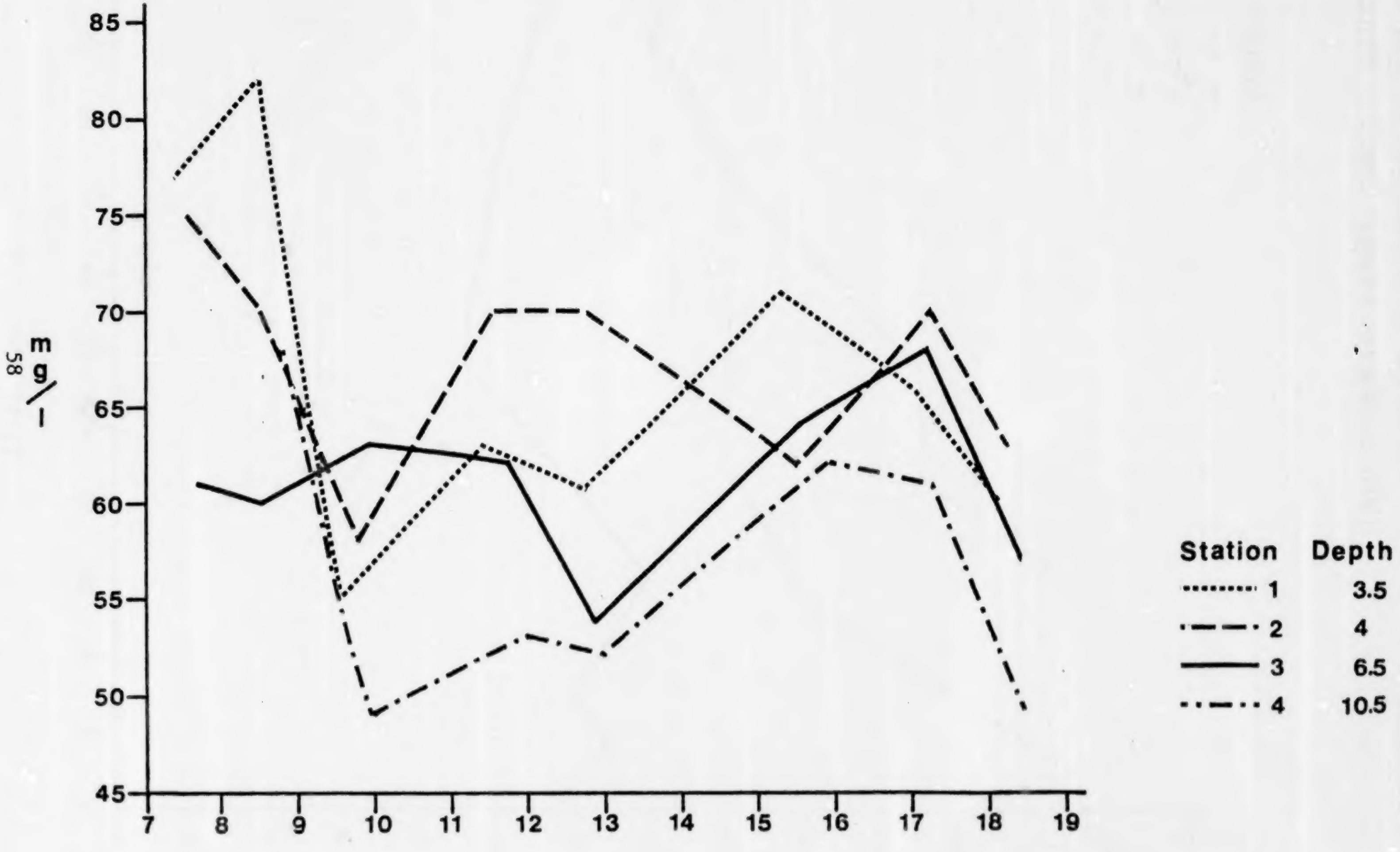


FIGURE 15 DAILY CHANGE IN TOTAL RESIDUE SEPT. 14, 1981
(Wind-Wave Study-Gentle Wind)



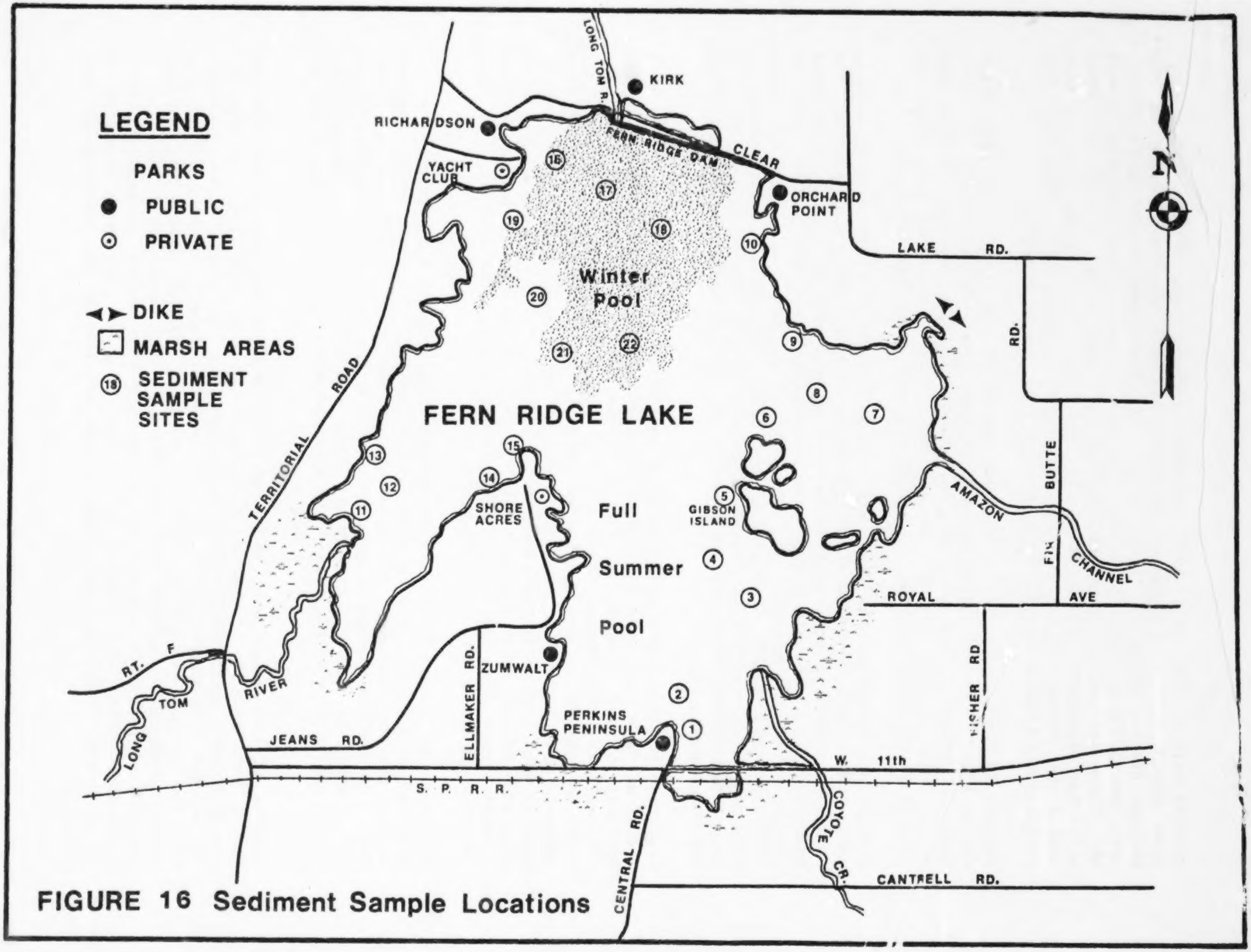

LEGEND
PARKS
● PUBLIC
⊙ PRIVATE
DIKE
MARSH AREAS
⑱ SEDIMENT SAMPLE SITES
N
FERN RIDGE LAKE
Winter Pool
Full Summer Pool
LONG TOM R.
KIRK
RICHARDSON
FERN RIDGE DAM
CLEAR
LAKE RD.
ORCHARD POINT
YACHT CLUB
RD.
BUTTE
AMAZON
FIR
CHANNEL
ROYAL
AVE
FISHER RD
W. 11th
GIBSON ISLAND
SHORE ACRES
ZUMWALT
PERKINS PENINSULA
ELLMAKER RD.
JEANS RD.
S. P. R. R.
TERRITORIAL ROAD
RT. F
RIVER
LONG TOM
CENTRAL RD.
COYOTE CR.
CANTRELL RD.
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FIGURE 16 Sediment Sample Locations

covered with a thin (half inch) tan-brown surface layer of "weathered" clay. Tree stumps with roots exposed provided evidence of some erosion of the shallow areas. There was little evidence of deposition in the flats of that area and little evidence of trash. The natural and dredged channels through the flats did contain a deposition oozy silts (up to one foot deep). Those silts had apparently settled while the reservoir was full and had not been washed by channel flow into the reservoir minimum pool. That silt was probably all flushed from the upper reservoir by the end of winter.

Channel silt deposits may be a major source of the residue in Fern Ridge during winter. Particle size analysis of samples 1 through 5 (Table 12) shows that the deeper native soil samples contained little material coarser than silt. Some of the surface samples had higher levels of sand than the subsurface samples suggesting a fine deposition of sand (eg. sample 3).

Samples collected on the open flats showed little if any coarse organic matter, and only a few macroinvertebrates (round worms). Predictably the areas near marshes contained roots and organic debris, and the gradient between surface and undisturbed clay was more gradual. The channel silts (of samples 1 and 5) had such a high moisture content that any large dense material would easily sink through the silt, consequently coarse materials were not found. If samples had been collected from the bottom of the silt layer, immediately above the hard pan of the channel bottom, the sand content may have been higher.

Samples 6 through 9 were collected from Amazon Bay. The sand content was much higher in this area both from the surface and deeper samples (Table 12). The drainage channel nearest to Gibson Island was lined with cobble. The "channel" carrying Amazon Channel water through Fern Ridge was shallow and broad as opposed to the deeply cut channels in the Coyote Bay area. The channel also contained extensive deposits of coarse sand, large organic debris, tires and other trash from urban runoff. The trash, though unsightly when exposed, may be of use as habitat by fish during summer. Most is located in areas deeper than eight feet (during summer) and is not visible even under the clearest conditions in the reservoir.

The beach at Orchard Point Park was sanded several years ago. Even though the shore is more steeply sloped than Perkins Peninsula the sand still appeared well distributed between the approximate elevations of 367 and 375 feet. Sample 10 was taken below the sanded area and its particle size distribution was similar to Amazon Bay samples. Clay and silt content of the sediment inside and outside of the boat basin appeared much higher than that along the beach.

Samples 11 through 15 were collected from Long Tom Bay when river flow was fairly high and the reservoir elevation was about 360 feet. It was not possible under those conditions to cross the Long Tom Channel in the reservoir and collect samples from the lower elevations. Samples were collected from both the eastern and western sides of the bay. Like the Amazon Bay, the Long Tom Bay sediment contained less silt and clay than Coyote Bay. There was a noticably higher sand content at the surface than deeper sediment. A local resident reported that much of the surface sand had just been deposited by major storms in December and January that had flooded the reservoir to near capacity.

TABLE 12: PARTICLE SIZE DISTRIBUTION OF FERN RIDGE SEDIMENTS (%)

SAMPLE # (See Figure 17)	SAMPLE DEPTH (Inches)	APPROX. SURFACE ELEV.	% MOISTURE CONTENT	PARTICLE SIZE DISTRIBUTION CLAY/ SILT	VERY FINE SAND	FINE SAND	MEDIUM SAND	COARSE SAND	GRAVEL
1	0- 2	366	36	88	3	2	3	1	1
Channel Silt)	0 -6	358	55	93	2	3	*	*	1
2	0- 2	367	28	89	3	3	2	1	2
	6-10	367	30	93	1	1	1	2	3
3	0- 2	369	20	57	17	13	4	7	2
	6-10	369	18	83	4	5	1	4	3
4 (Channel Silt)	0- 6	359	43	72	9	6	3	7	3
(hard pan)	0-10	359	18	45	15	19	10	4	7
5	0- 2	361	20	37	20	23	12	7	2
	6-10	361	20	89	1	2	1	3	4
6	0- 2	371	23	28	16	28	17	10	*
	6-10	371	20	50	14	16	9	11	1
7	0- 2	366	23	37	21	23	13	6	0
	6-10	366	29	54	12	12	9	8	*
8	0- 2	363	30	78	9	8	4	1	*
	6-10	363	23	45	12	21	13	6	3
9	0- 2	270	25	37	13	18	12	13	7
10	0- 4	365	23	47	10	11	9	17	6
11	0- 2	368	43	61	3	3	6	24	3
12	0- 2	368	25	39	24	23	10	4	1
	6-10	368	28	68	9	10	6	6	2
13	0- 4	372	21	13	17	40	24	6	*
	6-10	371	21	45	17	20	11	4	3
14	0- 4	370	20	31	16	25	13	8	6
15	0- 4	362	43	76	12	6	3	3	*
16	0- 3	349	72	97	*	1	*	1	0
17	0- 3	351	68	96	1	1	1	1	*
18	0- 3	349	70	98	*	*	1	1	0
19	0- 3	355	67	91	4	2	1	2	0
20	0- 3	356	66	63	10	12	6	8	*
21	0- 3	354	51	90	1	1	1	7	0
22	0- 3	350	60	97	*	*	*	1	0

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*Less than .6%

The east side of Long Tom Bay along Jeans Peninsula had a steep sandy shore. Lower elevations were affected by a flood channel the Corps of Engineers cut from the historic Long Tom Channel to the east side of the bay. The additional flow has resulted in a series of broad shallow braided channels between Jeans Peninsula and the historic channel. Those channels contained unconsolidated deposits of sand. Sample 15, taken from a low elevation off the point of the peninsula, was an oozy clay-silt reminiscent of the Coyote Bay samples, except that it appeared a uniform gray to a depth of over 14 inches. It may be the result of silt deposits rather than weathering of bottom clays. Subsequent field investigation around the shores of Jeans Peninsula showed high levels of sand in the sediment from Zumwalt Park around the other side of the peninsula. Shoreline erosion was significant and the eroded material appeared to contribute to the sandy substrate.

Deep pool samples collected with the Peterson Grab (samples 16-22) had very high water content (51 to 72%) and were an almost pure silt/clay mixtures. Heavier particles also would quickly sink through that oozy sediment. The one sample which contained a significant amount of sand (sample 20) was located in the path of the Long Tom River and probably contained recent deposits. The pool bottom material in general lacked consolidation and would take little disturbance to entrain.

The sediment samples were also used for settling experiments. Sediment was mixed with tap water and allowed to settle undisturbed. In all of the samples taken from exposed sediment, the clay portion remained in suspension for several months. Somewhat surprisingly, the pool silts tended to settle out in one to two weeks, indicating a lower clay content.

BACTERIA AND OXYGEN DEMAND

Bacteria and dissolved oxygen levels are two of the most critical measures for the national swimmable-fishable water quality goal. High coliform bacteria counts indicate the risk of communicable disease. Depleted oxygen concentrations can threaten fish life and lead to undesirable chemical reactions. The minimum oxygen standard for protecting warmwater fish is 5 mg/l in Oregon.

Sewage and animal wastes are the primary sources of bacteria and oxygen demanding material. The tributary contribution of those materials has been discussed in Section V. Bacteria were not found to be a problem at any station during summer (Table 13), however, winter levels were regularly excessive and spring levels frequently exceeded the state standard of 250/100 ml.

High bacteria counts in Perkins Bay during spring suggest a source of contamination not measured by stream monitoring. Use of the adjacent wetland by livestock is the most likely source although failing individual disposal systems and wildlife usage could make significant contributions. Another indication of failing disposal systems was found when collecting sediment samples in Long Tom Bay. A small drainage channel, which runs near and parallel to the western (developed) shore, contained a significant growth of algae while a second small parallel drainage further from the shore and draining a marsh contained no algae growth. Water sample containers were

TABLE 13: MEAN SEASONAL OXYGEN AND BACTERIA RELATED LEVELS - FERN RIDGE RESERVOIR

STATION	Temperature °C	DO mg/l	BOD mg/l	TOT COLI/100ml Median	TOT COLI/100ml Maxium	FECAL/COLI/100ml Median	FECAL/COLI/100ml Maxium
SPRING FILLING SEASON (Feb-May)							
Amazon Bay	13.9	9.8	3.4	84	200	* 10	90
Coyote Bay	13.0	10.3	3.3	100	400	60	260
Perkins Bay	13.0	9.6	3.2	350	1400	200	560
Long Tom Bay	12.7	9.8	3.3	70	350	25	100
Pool Surface	11.4	10.6	3.4	100	1100	20	700
Pool Bottom	10.9	10.6	3.1	*100	900	18	540
SUMMER CONSERVATION SEASON (Jun-Sep)							
Amazon Bay	20.6	8.6	2.6	20	80	12	30
Coyote Bay	21.7	8.7	3.1	20	60	5	5
Perkins Bay	21.2	8.6	2.7	15	60	* 7	10
Long Tom Bay	21.1	8.8	3.0	30	120	* 5	10
Pool Surface	21.6	8.8	2.7	40	25	* 5	ND
Pool Bottom	20.3	6.6	2.5	40	15	* 5	ND
FALL/WINTER FLOOD CONTROL SEASON (Oct-Jan)							
Pool Surface	10.3	10.3	4.1	1185	4610	670	2430
Pool Bottom	10.0	9.8	3.0	2560	3140	770	2223

unavailable so no determination was made on the presence of bacteria in that particular drainage. However, the Long Tom Bay did not exhibit problems even in the spring and septic tank failures are presumably a minor source of reservoir contamination in that area.

Biochemical oxygen demand (BOD) and chemical oxygen demand (COD) are crude indicators of the organic (and inorganic) pollutant load. Ultimate BOD rather than the more common five day BOD was measured to try to examine the total load. Ultimate BOD averaged slightly less than 3 mg/l in summer and slightly more than 3 mg/l in spring and winter. The State standard for BOD-5 is 4 mg/l so the load, though higher than many Oregon lakes, was not excessive. No standards exist for COD, but the average of about 10 mg/l at reservoir stations also indicate a higher than typical oxygen demand.

The measured oxygen levels were normally high, but as Table 13 indicates, there was some evidence of depletion in the pool bottom during summer. The shallowness and rapid mixing of Fern Ridge may be the only factors precluding significant oxygen depletion in the deeper areas. The minimum recorded deep pool value was 2.8 mg/l dissolved oxygen (June 23, 1982) All other deep samples met the 5 mg/l standard.

NUTRIENTS

Although nutrient concentrations for nitrogen and phosphorus tend to be higher during winter than summer, they were not high when compared with values for eutrophic lakes. Table 14 shows average seasonal levels in Fern Ridge. Nitrogen and phosphorus values were nearly equal during spring and summer, which indicates nitrogen rather than phosphorus is probably a limiting nutrient to algae growth. Generally, nitrogen concentrations in the Long Tom Bay and the deep pool samples were higher than the other sites (Table 14). The ortho-phosphate concentration was slightly higher in Coyote Bay than elsewhere.

Table 8 in Section IV showed that the daily reservoir inflow and outflow of nutrients was about equal during the heaviest runoff in February. Other spring samples had the inflow load exceeding the outflow as water was being stored in the resevoir, but the nutrient supply in the reservoir did not increase in proportion to the net increase of loading. The discrepancy may be accounted for by nutrient uptake by plants and probably some settling of nutrients associated with suspended particles.

The monitoring data indicate a significant part of the nitrogen in Amazon and Coyote Creeks enters the reservoir as ammonia (20 percent) but is rapidly oxydized in the reservoir environment to nitrate and nitrite. Ammonia was not detected in the reservoir. The nitrogen loading shown in Table 15 includes both ammonia and nitrite-nitrate nitrogen, although some of the ammonia may be lost as a gas. Table 15 was prepared using average seasonal tributary flow and nutrient concentrations. In spring, greater proportion of nitrogen load comes from Long Tom and Amazon and higher phosphorus and ortho-phosphorus loads come from Amazon and Coyote Creek.

A hypothetical nutrient "budget" (Table 16) was prepared using average inflow, outflow and reservoir concentrations, and storage volume. During spring

TABLE 14: MEAN SEASONAL NUTRIENT CONCENTRATIONS - FERN RIDGE RESERVOIR

STATION	Phosphorous Tot. mg/l-P	Orthophos mg/l-P	NO2+NO3 mg/l-N	Chlorophyll-a Corr. ug/l	Iron mg/1
SPRING FILLING SEASON (Feb-May)					
Amazon Bay	.053	.009	.040	.45	.658
Coyote Bay	.048	.009	.049	.43	.721
Perkins Bay	.062	.010	.048	.45	.752
Long Tom Bay	.040	.008	.096	.29	.444
Pool Surface	.052	.011	.065	.38	.519
Pool Bottom	.059	.013	.091	.45	.749
SUMMER CONSERVATION SEASON (Jun-Sep)					
Amazon Bay	.036	.013	.011	.75	.328
Coyote Bay	.039	.015	.013	.66	.380
Perkins Bay	.040	.011	.018	.83	.375
Long Tom Bay	.038	.009	.012	.86	.308
Pool Surface	.028	.008	.013	1.22	.268
Pool Bottom	.035	.011	.015	.91	.330
FALL/WINTER FLOOD CONTROL SEASON (Oct-Jan)					
Pool Surface	.092	.024	.159	-	1.431
Pool Bottom	.091	.020	.116	-	1.467

TABLE 15: TRIBUTARY DISTRIBUTION OF INFLOW AND THE NUTRIENT LOAD

SOURCE		INFLOW	NITROGEN	PHOSPHORUS	ORTHO-P
			SPRING FILLING (Feb.-May)		
AMAZON	%	4.9	5.6	7.1	8.2
COYOTE (& DIRECT)	%	42.2	37.4	60.0	67.2
LONG TOM	%	52.9	57.0	32.9	24.6
			SUMMER CONSERVATION (Jun.-Sept)		
AMAZON	%	2.8	1.5	3.9	3.4
COYOTE (& DIRECT)	%	16.2	14.5	19.9	14.3
LONG TOM	%	81.0	84.0	76.2	82.3

TABLE 16: HYPOTHETICAL NUTRIENT BUDGET DURING FERN RIDGE FILLING AND CONSERVATION SEASONS

SOURCE	NITROGEN kg	PHOSPHORUS kg	ORTHO-P kg
	SPRING FILLING (Feb-May)		
INFLOW	35,600	17,000	6,100
STORAGE END OF MAY	6,700	4,600	1,200
OUTFLOW	9,700	7,100	1,200
	SUMMER CONSERVATION (Jun-Sept)		
INFLOW	2,059	772	322
OUTFLOW	265	816	265

filling, 54 percent of the nitrogen, 31 percent of the phosphorus and 61 percent of the ortho-phosphorus flowing into Fern Ridge are not accounted for in storage or outflow. That difference represents net plant uptake and settling as well as sediment exchange, gaseous exchange and other nutrient cycling processes which are complex bio-chemical reactions.

The input of nutrients is much reduced during summer (June through September). The projected inflow and outflow of phosphorus and ortho-phosphorus are about equal but the nitrogen inflow is eight times greater than outflow. This would indicate, by the high rate of "consumption" in the reservoir, that available nitrogen is a limiting factor to plant growth.

Iron is also a major trace element in plant growth, but rarely is a limiting factor. The iron concentrations in Fern Ridge decrease dramatically from winter to summer (Table 14). A significant amount of plant uptake and settling probably both occur. However, the lowest iron concentrations remain well above limiting levels.

PLANKTON

Biological studies of plankton were conducted to characterize the trophic level of Fern Ridge and to examine the role of plankton in the turbidity problem. The light-dark bottle oxygen evolution technique was used to determine primary production levels. The data from three dates, when computed as a gross daily rate of carbon fixation, involve assumptions about the portion of daily production measured. Daily production varies with incident solar radiation and time of day. Phytoplankton are more active early in the day than later on. The actual portion of daily production measured could deviate by as much as 30 percent because radiation was not measured. The error factor shown below pertains only to laboratory accuracy in measuring dissolved oxygen. The approximate gross primary productions of 900, 1535 and 724 mg carbon/m2/day were computed (Table 17) for June 23, 1981, July 20, 1981 and August 24, 1981 respectively. Few guidelines exist to compare primary production values but commonly the average summer value is used. The Fern Ridge average of 1050 mg-carbon/m2/day would be classified as eutrophic according to Porcella, et al. (1980). This is in contrast to an evaluation below based upon chlorophyll-a concentration which fell into the oligotrophic range.

Chlorophyll-a measurements were made throughout the summer of 1981. Average values are listed in Table 14. During spring chorophyll-a averaged less than 0.5 ug/l and during summer averaged about 1 ug/l. The concentration was slightly lower in Coyote Bay which also had the highest turbidity. Those low chlorophyll-a and high turbidity levels suggest plankton were not a major source of that turbidity. Turbidity from clay may actually be inhibiting plankton growth. Values for chlorophyll-a from surface and bottom samples in the pool were nearly equal except in September. The plankton appeared to be well distributed in the water column, even below the photic zone.

In September, a small bloom was detected with a peak chlorophyll-a concentration of 4.8 ug/l in surface water at the pool monitoring site. In mid-October with the pool drawn down significantly, large conglomerations of plankton were visible throughout the deep pool area, but chlorophyll

TABLE 17: PRIMARY PRODUCTION MONITORING - VITAL STATISTICS

	June 23 1981	July 20 1981	August 24 1981
SKY COVER	100%	40%	60%
MAXIMUM AIR TEMPERATURE °C	20	31.5	25
WATER TEMPERATURE °C	20	22	23
TRANSPARENCY SECCHI(m)	0.9	1.65	0.6
INCUBATION PERIOD	10:00-16:15	10:45-14:30	11:00-16:00
ESTIMATED PORTION OF DAILY PRODUCTION	60%	40%	55%
GROSS PRIMARY PRODUCTION BY DEPTH (mg C/M^3/day)			
Depth			
0.3 m	390	469	369
0.9 m	390	391	284
1.5 m	313	352	227
3.0 m	94	414	142
4.6 m	53	16	0
INTEGRATED GROSS PRIMARY PRODUCTION mg-C/m^2/day	900 ± 150	1535 ± 340	724 ± 180

FORMULA USED:

$$\text{Primary Production mg } C/M^3/\text{day} = \frac{0_2\text{Light Bottle} - 0_2\text{Dark Bottle} \times 1000 \times 12}{PQ=1.2 \qquad \text{X time portion} \qquad 32}$$

measurement had been suspended. That bloom may have resulted either from the reservoir releases and sediment turnover or storm runoff contributing additional nutrients.

Studies were also conducted on the plankton community assemblage found in Fern Ridge. The filamentous diatom Melosira was the dominant plankton genera. Two distinct species were present--one was most likely a variety of M. granulata but the other species could not be determined. They are listed as Melosira #1 and #2 respectively. The other prevalent plankton were blue-green algae, which also were only positively keyed to genera. One type was the filamentous Oscillatoria sp. and two were from the genus Anabaena. All other taxa recorded were in low numbers. They are listed in general order of dominance in Table 18.

Most of the genera found are listed as potentially associated with, or responsible for water quality problems (Taylor, et al. 1981). Blue-green algae are capable of fixing their own nitrogen from the air and thus can avoid the nitrogen limitation factor. Several species also cause taste and odor problems when present in large numbers. Attempts were made to quantify the plankton population, however, it was not practical to count individual cells in filamentous colonies. Therefore, counts represented individuals of non-filimentous species and colonies (10 or more cells) of filimentous species. Counts averaged a little over 500 per liter. There was no significant relation between chlorophyll-a values and plankton counts except that the September counts, when chlorophyll-a peaked, were all above average. The species distribution was nearly the same throughout the lake on each sample date. Figure 17 shows the distribution of combined counts for each sample date for the five predominant plankton.

McHugh (1972) conducted a brief study on Fern Ridge and observed basically the same community assemblage, a major exception being a dominance of Aphanizomenon flos-aquae rather than Anabaena. McHugh concluded that those species being characteristic of highly enriched situations indicated Fern Ridge was certainly highly enriched. He attributed low nutrient concentrations of phosphorus and nitrogen to "bloom" conditions where nutrients were locked up in phytoplankton. While this study corroborated the predominance of genera that indicate eutrophic conditions the chlorophyll-a concentration and low numbers of plankton fail to indicate bloom conditions.

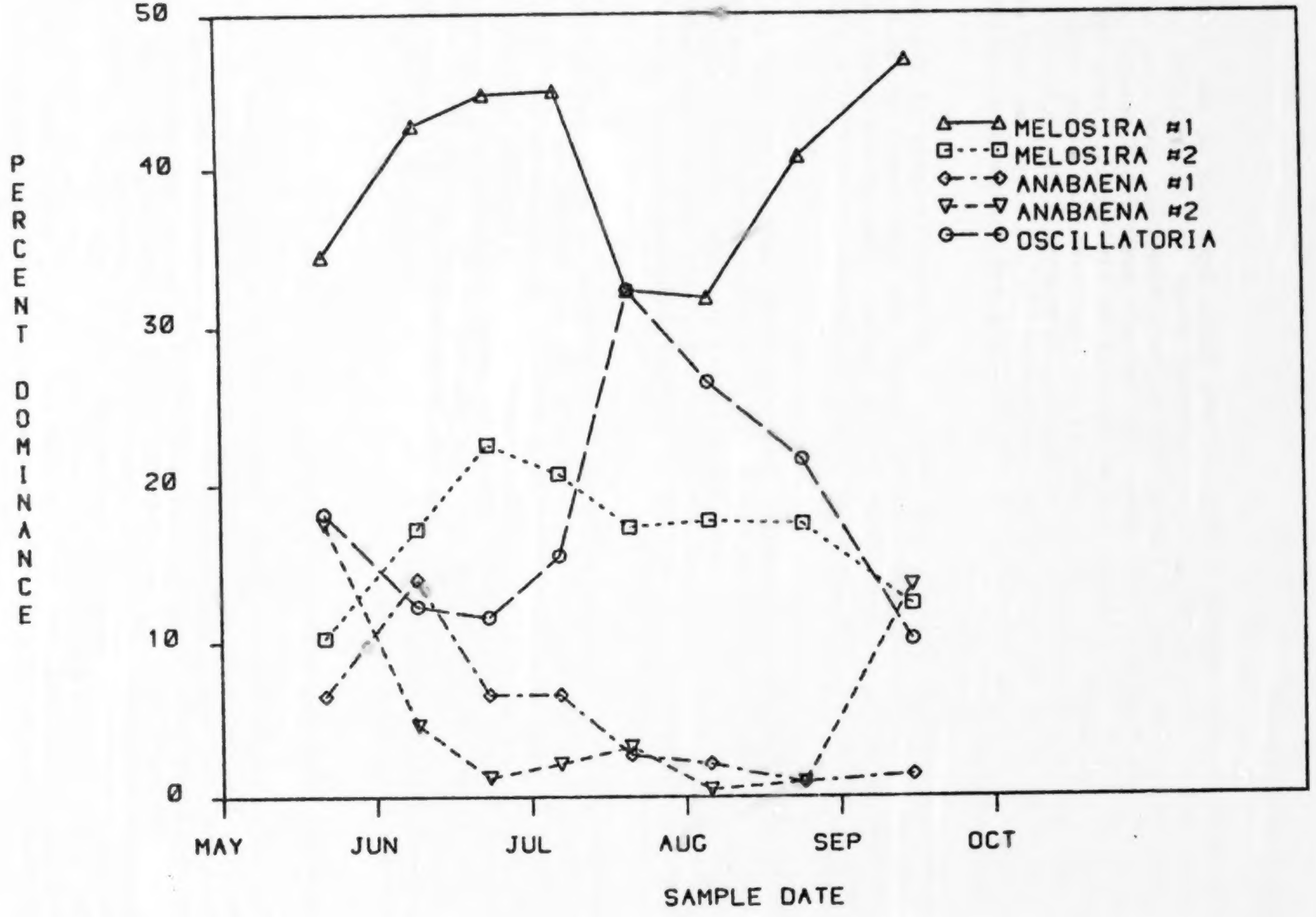
In examining both nutrient and phytoplankon data it appears Fern Ridge does not have a major problem with plankton growth at this time. A decrease in turbidity may result in additional algae production due to the greater photic zone but low nutrient levels may preclude excessive blooms. It appears that the major portion of the nutrient load may be tied up in the extensive macrophytic plant growth of the shallow wetlands rather than plankton.

Zooplankton were also enumerated in this study and five families were present. The count in April was 10 times greater than the average for the rest of the summer (21 vs. 2.1 per liter respectively). The summer average count was not high. Porcella, et al. (1981) recommend that 25 zooplankton/l be considered an indicator of eutrothic conditions. The zooplankton were also distributed relatively evenly throughout the reservoir and from bottom to top in the deep pool. Taxa present included Cyclopoid, Calanoid, Daphnia, Bosima and Leptodora.

TABLE 18: PLANKTON TAXA IDENTIFIED IN FERN RIDGE RESERVOIR

LARGE NUMBERS PRESENT	TYPE
Melosira #1 (granulata)	- diatom
Melosira #2	- diatom
Oscillatoria	- blue green
Anabaena #1 (spiroides)	- blue green
Anabaena #2	- blue green
FEW USUALLY PRESENT	
Stephandodiscus	- diatom
Navicula	- diatom
Scenedesmus (quadricauda)	- green
Asterionella (formosa)	- diatom
Nitzschia	- diatom
Pediastrum	- green
Synedra	- diatom
Euglenoid	- green
OCCASSIONALLY PRESENT	
Gyrosigma	- diatom
Cocconeis	- diatom
Surirella	- diatom
Keratella	- dinoflagellate
RARELY PRESENT	
Ceratium	- dinoflagellate
Ankistrodesmus	- green
Tabellaria	- diatom
Anabaempsis	- blue green
Diploneis	- diatom
Gomphonema	- diatom
Micrasterias (?)	- blue green

FIGURE 17 DISTRIBUTION OF DOMINANT PHYTOPLANKTON
MAY - SEPTEMBER 1981



SECTION VII. WATER QUALITY ENHANCEMENT ALTERNATIVES

PROBLEM STATEMENT

~~Sediment~~
Turbidity

The primary water quality problem in Fern Ridge Reservoir is the turbid muddy brown water. During summer the shallower areas in the vicinity of Perkins peninsula are at times so turbid that objects disappear from view within one foot of the surface. This makes the beaches undesirable aesthetically for swimming and a safety hazard due to the lack of visibility. Even the deepest waters can have visibility reduced to two feet, creating objectionable conditions for both boaters and swimmers. Turbidity is the combined result of fine clays in permanent colloidal suspension, larger clays and silt which are present in varying quantities due to settling and resuspension, and moderate levels of planktonic growth.

Coliform

Secondary problems include high levels of coliform bacteria in the backwater sections of Coyote Creek and Amazon Channel and high levels of bacteria and extreme turbidity in Fern Ridge during winter. The winter conditions have minimal effect on human use of the reservoir because of limited access to the water.

Potential problems could occur from the heavy metals, oil and grease and industrial wastes that enter Fern Ridge through Amazon during storm runoff or spills, but the load of toxic material reaching the reservoir during spring and summer is generally small and within acceptable limits. The lower Amazon corridor, however, is zoned for industrial development which could increase the risk of toxic contaminants.

Algae

Another potential problem is the possible increase in algae growth that could result from reducing the clay and silt content of the water. Some of this study's findings suggested plankton growth was restricted by the availability of light. It is unclear whether there is a sufficient nutrient base to support problem increases in growth by merely improving water clarity. If algae blooms become a problem, the sources of nutrients would need to be controlled. Long Tom River and Amazon Channel have the highest nitrogen concentrations, while Coyote Creek and Amazon Channel have the highest phosphorus concentrations.

MEASURES TO REDUCE CLAY-SILT TURBIDITY

The native clay-silt sediment appears to be a major source of suspended solids, but the loosely consolidated silt and clay that settles in the deeper pool and river and drainage channels may also contribute to the problem. Wind waves appear to be a predominant force in suspending the sediment. However, high turbidity levels also occurred during periods of calm. The lowering reservoir elevation toward late summer also contributes to the impact of waves on the sediment by exposing unvegetated lake bottom to strong wave forces. Two other factors are likely to cause lakewide suspension of sediments; motor boating in the shallower areas and bottom foraging fish. Local problems are increased as a result of unsanded swimming beaches and shoreline erosion.

Methods of reducing suspended solids include changing the water chemistry to increase the settling rate of solids, changing the bottom sediment, making physical alterations that reduce wave impacts, and controlling human and biological contributions to turbidity. Some of the alternatives are more of a cure-all than others, but the actions which would be most effective are also generally the most costly and labor intensive. Some of the alternatives need to be tested further to determine their effectiveness and side effects.

Chemical Treatment

Several chemicals were added to sediment sample mixtures described in Section VI to determine their impact on settling rates. Each test resulted in clear water within two hours to three days of the chemical additions. Chemicals tested included NaCl, CaCl, Alum, MgO and CaCO3. A 0.1% solution of each was added to the sediment samples. The calcium carbonate was the slowest acting but it also appeared to bind the settled clays more tightly than other chemicals. It is not likely to have undesirable side effects that salts would have.

Alum is known to remove phosphorus from the water as well as the clay. Alum could potentially assure that improved clarity would not lead to excessive algae growth. It may, however, produce a slimey coating or a bottom sediment that is easily clouded by physical disturbance. Chemical additions would be effective for a limited duration, probably not more than one year. Winter rains and reservoir flushing would tend to remove chemicals from the exposed sediment. Selective application of chemicals to swimming areas, in combination with other measures, may help provide local clarity that is desirable for recreational use. Large doses of salts could also be used in emergency situations to clarify small areas. It would be desirable to test some of these chemicals on a small scale within the reservoir to determine their effectiveness in the natural water and the type of sediment/water interface produced. Chemical treatment may represent an effective, low cost maintenance option, especially if it can be applied to limited areas such as Perkins Peninsula and Coyote Bay.

Reservoir Dredging

Deepening of the reservoir has been suggested by DEQ and recreationalists for various reasons. However, dredging to remove clays or increase depth lakewide would be a large scale operation. The clay layer appears to be five to eight feet thick and cover several square miles of reservoir bottom. Even when only considering deepening the shallow areas to eight feet deep (365 foot elevation) by dredging and backfilling the higher elevations, it would involve moving at least 12 million cubic yards of clay. For the most part, the bottom would still be clay and the wetland areas which contribute significantly to water quality as well as wildlife management would probably be filled or cut off from the reservoir. Also, without further investigation there could be no guarantee that the additional depth alone would reduce the clay turbidity.

Two beneficial results would be decreasing the water lost to evaporation by reducing surface area, and increasing sailboat access to dredged shallow areas of the lake. However, economic and environmental justification would have to be developed for a major multi-million dollar dredging project. Dredging would probably be most effective in conjunction with a diking project.

Vegetation Management

Aquatic plants can have a significant affect on reducing turbidity by binding the sediment and dampening waves. Additional large plants would also tend to further reduce nutrients available for plankton growth. Plant growth in Fern Ridge is restricted by the reservoir drawdown during winter. Only emergent plants such as bullrush, cattail and Reed canary grass thrive and survive with winter freezes and the exposed ground. Those plants presently grow out to elevations of 368 to 370 feet (3.5 to 5.5 feet deep at conservation pool). Most areas higher than the 370 foot elevation have a solid growth of wetland vegetation. Lower elevations have more scattered growth and no significant rooted vegetation is found below the 367 foot elevation. The areas targeted for expanded vegetation should be based on the depth at which highest wind waves can disturb the clay and silt. Further study is required to determine that depth.

There are two basic means of encouraging plant growth in the deeper areas. New plant species could be introduced that are capable of growing during winter and being submerged during summer. The Corps of Engineers is presently experimenting with such plants in Blue River and other local reservoirs. A successful species for Fern Ridge would have to be a short plant. Species that grow taller than a foot or two would pose a significant interference with recreational boating if the area of growth could not be confined. Elevational or depth requirements for plant growth are particularly critical in Fern Ridge since the reservoir is so flat that small elevational differences in the area of potential growth could cover large areas of the reservoir.

A second method of encouraging vegetation would be to impound water during winter over the areas where vegetation was desired. A permanent pond would permit submerged and floating leafed plants to become established. The ponding could be created by constructing low, closed cell dikes which would be submerged up to three feet during summer. Dikes would isolate the areas where where vegetation was desired and feasible. Old submerged road beds could serve as a base for some dike construction. The dikes would also serve water fowl, and could be used for hunting and wildlife observation access during winter. In fact, similar proposals have been made for the sole purpose of wildlife management. Water quality improvement considerations and benefits should be included in such planning. The dikes would require markings for navigation warnings.

The value of submerged dikes over raised dikes would be to permit the aquatic vegetation to draw nutrients from the reservoir and not be totally cut off from it. Submerged dikes would also preserve the aesthetics of the marshes. The major drawback of closed cell dikes would be some loss of flood storage capacity and entrapment of fish in winter. The areas which presently lend themselves to closed dike systems are shown on Figure 3.

Open Cell Dikes and Islands

High dikes and islands could be constructed as a method of restricting circulation of turbid water from the shallow clay bottom areas without losing flood storage capacity. Dikes or islands constructed along the old Royal Avenue would greatly reduce the fetch and therefore the maximum wave height in Coyote and Perkins Bays. Another dike could follow the natural high contour of Amazon Bay (Figure 3). It may be possible to use the bottom clays, in part, for dike or island construction, but they would have to be sufficiently armored to withstand wave attack. Natural drainage channels would be left open to permit flow through of flood water during winter and boat passage during summer. It would also be important to maintain open natural channels to avoid creating pockets where sediments would tend to accumulate.

Open dike or island construction would be likely to improve water clarity on the side of the dike toward the dam by reducing the clay content of that water. It is uncertain whether the shallower areas on the other side of the dikes would be clearer due to decreased wave action or more turbid due to restricted circulation and factors other than wind waves stirring the bottom. The dikes, however, could provide some containment for chemical treatment of restricted areas. Creation of islands from adjacent bottom material could additionally serve as a means of increasing depth in desirable boating areas and as a recreational and aesthetic asset. Reduced waves would improve water skiing conditions, but waves from water skiing may also contribute to the suspended sediment load and not be desirable to encourage in some areas.

Changing the Bottom Composition

It may be possible to reduce the entrainment of silt and clay by applying a thin layer of sand especially to the shallow clay bottom areas shown in Figure 2. If sand application improved water clarity, a single application would probably have a relatively long term benefit because the areas are so flat. Sand probably would tend to work into the clay rather than be washed from the surface into the drainage channels.

Beaches are present areas that definitely should be sanded. The physical disturbance caused by swimmers would be a constant source of silt and clay in the very areas where demand for clear water is greatest. Perkins Peninsula Park is the most inadequate in this regard. A comprehensive beach improvement program for that park would include replacing up to one foot of clay with sand or sand and gravel and installing something such as a pile dike around the beach to dissipate wave action. Winter drawdown provides an opportunity to work on the beach with land equipment. Crude estimates indicate the improvements could probably be constructed for $200,000 to $500,000. Richardson/Kruger and other parks may also require sanding. Zumwalt and Shore Acres Parks are also suffering from shoreline erosion that adds to local turbidity. The erosion has, however, created sandier beach surfaces. Erosion control measures are warranted at those sites, because the recreational use precludes natural stabilization. However the steep concrete/asphalt shore armoring at other beaches has generated considerable criticism and alternative methods and designs should be investigated. Wave dissipates could reduce the erosive forces and improve swimming conditions.

Summer Flow Augmentation Into Fern Ridge

As was illustrated in Table 9, water losses exceed water inflow during July, August and September. The average deficit is 70 to 100 cfs and results in a drop in water level of up to three feet. More critically, the 368 to 370 foot elevations, which are unvegetated, become subjected to strong wave action. The water drawdown effect may partly explain the observations of higher turbidity in July, August and September when compared with May and June.

The most feasible source of flow augmentation is the proposed Emerald Canal. The canal would pass through downtown Eugene, diverting up to 200 cfs from the Willamette River through the Amazon Channel. The water could then be directed into Fern Ridge or the lower Amazon Channel. Additional flow to Fern Ridge would be sufficient to maintain a full pool under normal conditions. The water from the Willamette River would also be clearer than that in Fern Ridge, but passage through Eugene and the Amazon Channel would subject it to many potential pollution sources. Urban runoff controls and industrial site management would take on greater importance. The addition of clearer water would be most visible in Amazon Bay and Orchard Point Park.

The other method of flow augmentation would be water storage for release during summer. Several reservoir sites were identified in the old Upper Willamette Basin report (Oregon Water Resources Board 1961). A comparison of those sites with current land use shows most that are large enough to aid in flow augmentation now contain many small acreage, rural residential developments. Only one site on upper Poodle Creek and one on upper Spencer Creek appear to have minimal land use conflict. The combined potential flow augmentation of those two sites would not be fully adequate to maintain the conservation pool level. If there were active storage proposals in the Long Tom or Coyote basins, water quality benefits should be assigned for any flow augmentation to Fern Ridge during July through September.

Control of Bottom Foraging Fish

Large numbers of carp, suckers and bullheads are found in Fern Ridge. Further study is needed to determine their role in disturbing the sediment. Since they live throughout much of the basin, total elimination of those species would be a major undertaking. Alternative control could include commercial harvest. During winter the fish are concentrated in the minimum pool and a commercial operation would not face a major conflict with recreational fishing. Fishing clubs would need assurance that game fish were being returned to the reservoir unharmed. Consideration would also need to be given to the potential effect of reduced rough fish populations on the Osprey that nest at the reservoir.

Boating Restrictions

Motor boats may at times contribute to shore erosion and be a source of disturbance of bottom sediments. In addition to wave impact studies suggested earlier, a separate application of the findings of Yousef, et al. (1978) on the impacts of boating in shallow lakes should be made for Fern Ridge. If motor boat size or sped creates a substantial turbulence in the shallow clay bottom area, restrictons would be warranted (see Figure 3). At present boating wave impacts appear minor when compared with wind waves or fish disturbance.

MEASURES TO REDUCE BACTERIA (BACKWATERS/WINTER)

Coliform bacterial waste loads originate primarily from animal wastes in the Amazon Channel and Coyote Creek. During summer, high levels in the Amazon are probably due mostly to wildlife usage of the stagnate ponded water. Winter storm runoff in Amazon Channel would probably include pet wastes and a limited amount of leakage or improper connection of sanitary sewer lines. The level of bacteria in Amazon Channel is high but not acute. Control should be included in an ongoing monitoring and maintenance program that would identify and track sewer line leaks in particular (Rosenthal and Kreag 1982).

The Amazon Channel should be posted to warn users of potential health problems. The Channel itself presently functions to passively treat urban runoff wastes, a role that is considered beneficial by some. Flow augmentation by the proposed Emerald Canal would create a demand for higher quality water within the channel and high bacteria levels would require stricter control.

The Coyote Creek bacteria levels result from livestock waste runoff. State Soil and Water Conservation Division staff found one major source to be a large cattle yard. They are working to find a solution. As in the case of urban runoff, additional bacterial contamination is expected to arise from multiple sources. Smaller acreage farms with a few livestock often do not adequately provide for waste control or barn yard drainage. Correcting the lower level problem would involve extensive field work and assistance to farmers in identifying problems and solutions. Coyote Creek backwaters should be posted to warn of public health risks.

POTENTIAL PROBLEMS

Algae Growth

The potential for problem algae growth exists in Fern Ridge. The Corps of Engineers should be prepared to investigate complaints of nuisance algae blooms, by collecting water samples for analysis of nutrient levels, chlorophyll-a, and plankton species. If control becomes warranted, action should focus on reducing the input of nitrogen and phosphorus during spring filling. Harvesting of channel vegetation could provide some reduction of nutrients from Amazon Channel (Kreag and Rosenthal 1982). Livestock waste control could reduce loads from Coyote Creek, Long Tom River and direct drainages. It may also be possible to use wetlands for nutrient removal from the Veneta sewage system.

Toxic Wastes

The basin connection of Eugene with Fern Ridge through the Amazon Diversion Channel presents a constant potential for toxicants reaching the reservoir. Toxic spills have resulted in fish kills as far downstream as Fir Butte Road (Figure 2) in the Amazon. The diversion structure at the USGS gage near Royal Avenue provides a potential location for diverting or containing spills from flowing into Fern Ridge. A portable structure could be designed to temporarily dam the Amazon flow while dangerous spilled materials were removed. Local spill contingency preparedness would help minimize impacted areas. Commercial and industrial site drainage plans and hazardous material handling procedures would reduce the threat of spills and storm runoff contamination.

Other high potential risk areas for toxic spills include the Southern Pacific Railroad Line and Highway 126. State officials are generally called in rapidly in the case of highway and rail accidents. Sources of containment and clean up materials should be well documented so local officials can put them to use when necessary.

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Appendix A

PUBLIC AND AGENCY INVOLVEMENT

lcog Lane Council of Governments
NORTH PLAZA LEVEL PSB / 125 EIGHTH AVENUE EAST / EUGENE, OREGON 97401 / TELEPHONE (503) 687-4283

FERN RIDGE SURVEY PARTICIPANTS

Thank you for taking time last August to complete a survey on water quality and your use of Fern Ridge Reservoir. Through our overall study we are identifying the types and sources of water degradation in Fern Ridge and hope to propose some realistic ways to improve it. The survey results have given us a better grasp on how people feel about the murkiness of the reservoir. We also have a better idea of how cleaner water would affect people's use. A summary of the survey results is enclosed. Swimming and sunbathing were listed more often than other activities at Fern Ridge and were frequently ranked the most important uses. About half of the people think there is a significant water quality problem, and even more say they would use the reservoir more (especially for swimming) if it were cleaner.

We received several good suggestions for remedial action. Most water cleanup measures we were considering are listed. We will be studying the cost and the potential improvement from these measures in the coming year.

To date, our water quality sampling has not shown a major problem with bacteria, algae or toxics in the water. The plants (cat-tails, grasses, etc.) in the shallow water probably use most of the nutrients that enter the reservoir. Summer storms could add chemicals which cause algae blooms but there was no rain last summer. The problem is primarily turbidity. Silt and clay on the lake bottom are stirred up by winds, people and probably fish. Motor boats do not appear to be a major cause of the problem. The clay remains in suspension and is circulated throughout the reservoir. Very little of it settles out once disturbed.

In our sampling this winter and spring, we have found that the silts are both washed-in accumulated sediments and are naturally occurring soils within Fern Ridge itself. The southern end, between Zumwalt Park, Gibson Island and Perkins Peninsula, contains an almost pure clay bottom.

We will be working with the public, Lane County and the Corps of Engineers when it comes to recommending actions. You will be kept on the mailing list for future information. If you have any comments or questions about the survey or the water quality restoration study of Fern Ridge, please call or write.

Sincerely,

Gerritt Rosenthal
Program Manager

Becky Kreag
Becky Kreag
Project Leader

GR/BK:bp/[illegible]

Enclosure

cc: Corps of Engineers

L-COG CLEAN LAKES STUDY
FERN RIDGE
USER SURVEY SUMMARY

SURVEY DESCRIPTION

A simple survey questionnaire was designed to obtain a rough idea of user values and perceptions at Fern Ridge Reservoir.

Nine significant user areas were defined: Orchard Point, Richardson Park, Eugene Yacht Club, Kruger Park, Zumwalk Park, Fern Ridge Shores private camp and yacht club, Perkins Penninsula Park, the fishing area along West 11th and the wildlife area at the end of Royal Avenue.

The survey was handed out in person, with a brief introduction, on Saturday, August 22, 1981 between the hours of 7:30 a.m. and 8:00 p.m. Approximately representative numbers of surveys were distributed at each area according to the number of people present and among each obvious user grups (boaters, swimmers, fisherpersons, etc.) to minimize bias in the survey.

One hundred and forty-eight survey forms were passed out and 115 were received back immediately or mailed in. The following is a summary of responses:

A. USE ACTIVITIES (% of respondents indicating a use)
(multiple answers encouraged)

Use	%
Swimming	83
Sunbathing	79
Picnicing and general recreation	67
Relaxation/solitude	51
Social gatherings	51
Water skiing	40
Sailing	27
Motorboating	27
Camping	18
Fishing (shore)	15
Wildlife observation	15
Nature walk	12
Fishing (boat)	12
Canoeing, non-motoried boating	12
Exploring mud flats	10
Hunting	7
Other (walking dogs,sightseeing, etc.)	5

B. PERCEPTIONS OF PROBLEMS

		% Responses
1.	There is a water quality problem and cleaner water would encourage more personal use.	42
2.	There is a water quality problem but personal use would not be affected by improvement.	8
3.	There is not a water quality problem but cleaner water would increase personal use.	17
4.	There is not a problem and cleaner water would not increase personal use.	22
5.	People uncertain about whether a problem exists.	6
6.	People uncertain about whether cleaner water would increase use.	5
	TOTAL	100

C. USE PATTERN

	% Respondents
Summer Use	
Regularly	34
Frequently	26
Occasionally	27
Rarely	13
TOTAL	100
Winter Use	
Regularly	5
Frequently	4
Occasionally	12
Rarely	27
Never	52
TOTAL	100

D. LIMITATIONS ON USES OTHER THAN WATER QUALITY

	(# of Responses)
Travel distance	37
Overcrowding	25
Not a preferred park	23
Poor or inadequate facilities	14
Too windy	13
Conflicts with other uses	8
Work	5
Bees, yellow jackets	2
Short season	2
No nude areas	1
TOTAL	130

E. SUGGESTIONS FOR IMPROVEMENTS

	(# of Persons with the suggestion
Limit or prohibit motor boat use	10
Improve the muddy bottom (cement, gravel, sand)	9
Maintain water level longer in fall	7
Augment the flow (e.g., Emerald Canal)	6
Keep boats from swim area	5
Maintain water level year round	5
Clean the lake litter (e.g., annually)	4
Protected areas for children	2
Control pollution sources (i.e., to lakes & streams)	2
Provide more garbage cans	2
Control algae	2
Dredge shallow areas	2
Set higher water standards	2
Screen or filter boat trash from swim area	2
Eliminate vegetation	2
Limit Corps of Engineers authority	1
Resume pay parking	1
More small parks to spread use	1
Better control of draining and filling	1
Cut out irrigation	1
Find aquatic life to eat algae	1
Clean algae from cement	1
Prohibit dogs	1
Fine polluters and dumpers	1
Dike southeast corner for bird use	1
TOTAL	72

[illegible]

Lane Council of Governments
NORTH PLAZA LEVEL PSB / 125 EIGHTH AVENUE EAST / EUGENE, OREGON 97401 / TELEPHONE (503) 687-4283

October 8, 1981

TO: Neil Mullane

FROM: Becky Kreag/Gerritt Rosenthal BK GR

SUBJECT: Agricultural Runoff in Coyote Creek

On September 29, 1980, our normal Fern Ridge tributary sampling day (and two days following the end of a major storm), we found Coyote Creek to be extremely polluted from agricultural runoff (livestock wastes). At the head of the reservoir influence on Coyote Creek there was a strong odor of urea and many small fish were swimming at the surface. The DO sample showed 0.0 mg/l oxygen. As you can see from the partially completed lab sheets (attached), the ammonia, phosphate, chloride and bacteria levels were also extreme. Spencer Creek was not flowing at the time of sampling and a second Coyote Creek site, just above Spencer Creek had high but more typical parameter values.

We were unable to contact Larry Lowkenkron so we called Jim Hutchison at the local ODFW office. He investigated the following day and found DO levels of 0.2 mg/l. He called Glen Carter at DEQ and we presume that Larry Lowenkron is now aware of the situation.

We wanted to inform you of the details of this pollution incident as we would hope that major non-point problems such as this will be investigated. If such a storm had occured during the summer instead of just prior to reservoir draw- down, the impact on the upper reservoir could have been quite significant. Nearly all Fern Ridge pollutants are of non-point nature and it appears that there are inadequate controls for dealing with the agricultural component at this time. We would appreciate your advice on dealing with these matters.

BK:GR/jt/H2

cc: Glen Carter
Larry Lowenkron
Jim Hutchison

RECEIVED SEP 13 1982

STATE OF OREGON

DEPARTMENT OF ENVIRONMENTAL QUALITY

INTEROFFICE MEMO

TO: Joe McCray
State Department of Agriculture

DATE: September 8, 1982

FROM: Peter Ressler, DEQ
Water Quality

SUBJECT: Coyote Creek, Lane County

Attached is a memorandum we received from the Lane Council of Governments (L-COG) regarding agricultural pollution in Coyote Creek. We would hope that your Division would, in conjunction with the SWCD in that area, investigate this complaint. A voluntary compliance/resolution of this complaint would be within the role your Division is striving to assume in statewide animal waste management. The way you are working on resolving the Bashaw Creek pollution problem may also be appropriate for this complaint. More information on Coyote Creek may be obtained by contacting Becky Kreag at L-COG.

Please contact me if I can be of assistance.

TG1540

9/2/82 R.G.

At Fern Ridge Reservoir

Study finds way to clean up lake

By **DAN WYANT**
Of the Register-Guard

Even though Fern Ridge Reservoir west of Eugene may never be as sparkling clear as a Cascade Mountains lake, ways are available to reduce its summertime turbidity, or muddiness, a new study concludes.

Bacteria counts are low in the lake during summer months and no health threat was found to swimmers from human or animal wastes, the study says. However, backwater portions of Coyote Creek and Amazon Channel, two of the streams feeding into the Army Corps of Engineers' reservoir, "did contain high bacteria levels and other problems," a summary says.

The Lane Council of Governments conducted year-long testing of water quality at Fern Ridge to determine what problems exist and what actions can be taken to make the popular recreational reservoir cleaner, said Becky Kreag, council water quality planner.

A public meeting is scheduled for Wednesday at 7:30 p.m. at Harris Hall, 125 E. Eighth Ave., Eugene, to report on the study and take public comments. The meeting will be held by the council's Areawide Water Resources Advisory Committee.

"The committee wants to obtain public comment on the proposed measures to clean up the reservoir," Kreag said. "It also wants to hear whether the proposed improvement actions need to be changed because of major conflicts with reservoir use."

The study notes that the reservoir "is typically clearest in May and June. By August, most of the water is so turbid that anything deeper than a foot or two from the surface can not be seen. Such turbidity is not only unsightly and unpleasant to swim in, but it makes rescue of drowning persons extremely difficult."

The turbidity results mainly from the natural clay bottom of the lake in the shallow southeast portion of the reservoir around Perkins Peninsula Park, the study says. When the clay is stirred up, tiny particles become suspended in the water and "essentially never settle out," the study says.

"It is evident from laboratory studies that fine clays stirred up by swimmers at Perkins Park on one weekend will still be suspended in the

Turn to FERN RIDGE, Page 2C

staff photo by Harley Soltes

Fern Ridge Reservoir water may be murky but it's safe for these kids swimming near Perkins Peninsula

9/2/82 R. G.

Fern Ridge

Continued from Page 1C

water even a month later," the study says. "Waves and general lake circulation will disperse the muddy water from the beach to other parts of Fern Ridge."

The bottom can also be disturbed by waves caused by winds or by boats, by bottom feeding carp, suckers and bullheads and possibly by other causes, the study says.

Kreag said the L-COG study identifies a variety of possibilities for improving the lake's clarity, although some would be costly.

These range from building low dikes to separate the muddy portion from the main reservoir, hauling in sand to cover the clay bottom at swimming areas, trying to eradicate bottom-foraging trash fish, imposing boat speed regulations at the south end of the reservoir, encourage vegetation to grow in the shallow clay areas, or settling or stabilizing the clay by adding calcium or other minerals to the lake or by covering the shallow bottom area with a thin layer of sand.

No cost estimates were developed, she said. However, the Army Engineers are spending about $500,000 constructing dikes along some shore areas to encourage growth of plants that provide food for waterfowl. Dikes envisioned to seal off the clay bottom areas would be several times as extensive, so the cost would probably range between $1 million and $2 million for this measure alone, she said.

Construction of the much discussed Emerald Canal in Eugene to link the Willamette River with Amazon Channel could provide a flow of fresh water during the summer to keep the reservoir full and reduce the wave impacts in the unvegetated shallow areas, the study notes. The Amazon Channel would bring clearer Willamette water into the reservoir while turbid water could be released from the dam spillway, improving the lake's clarity, particularly in the Orchard Point Park area, the study says.

With Lane County short of money, any water quality improvement projects would probably have to come from Army Engineer operating budgets, Kreag said. "The Corps of Engineers wants their reservoirs to meet water quality standards," she said. "They seem willing to commit some level of funding to water quality."

Besides turbidity, the main problem turned up in the study was pollutants brought into the lake, especially in the fall and winter, from Amazon Channel and Coyote Creek. A third stream flowing into the reservoir, the Long Tom River, "normally has relatively clean, clear water and rarely exceeds state water quality standards," the study says.

Amazon Channel carries pollutants including lead from motor exhausts washed from city streets and discharged by storm sewers into Amazon Channel and thence into the lake; Coyote Creek discharges quantities of bacteria from livestock wastes into the reservoir, tests indicated.

"The inwash of manure (from Coyote Creek) was so strong following the first major fall storm of 1981 that oxygen was total depleted from the water (in Coyote Creek Channel) and fish were in distress," the study says. "The bacteria poses a potential health risk to users."

The study suggests that the state Department of Environmental Quality, the Soil and Water Conservation Service and area farmers work together to identify farms where livestock are causing contamination in Coyote Creek or its tributary, Spencer Creek, "so specific controls can be designed."

RESTORATION MEASURE ANALYSIS

Input from Agency Meeting 7/29 and 8/4, 1982

Meeting attendance 7-29-82, L-COG Conference Room, Eugene

Bert Clary, ODFW, Corvallis
Glenna Lee, Corps, Fern Ridge
James Beal, Corps, Fern Ridge
Dick Cassidy, Corps, Portland
Jim Hutchison, ODFW, Springfield
Jim Gree, ODFW, Springfield
Bill Guenzler, Eugene
Graig Starr, Lane County Parks
Harry Youngquist, Lane Co. Env. Mgt.
Sydney Herbert, AWRAC
Becky Kreag, L-COG
Ollie Snowden, L-COG

Meeting attendance 8-4-82, Corps of Engineers, Portland

Mat Rea, Natural REsources Branch Planning Div. (Master Plan)
Fred Bills, Fish and Wildlife Branch
Fred Pavillio, Recreation Res. Branch, Prog. Operations Div.
Jay Sturgill, Foundation & Materials Br., Engineering Div.
Dick Cassidy, Hydraulics & Hydrology Br., Engineering Div.

East Side Dikes (Closed Cell)

1. Require Navigation Markings/Not Much Boating Below Gibson Island.
2. Consider Mosquito Breeding Implications
3. How Much Is Flood Control Reduced By
4. How Much Cost (Corps Analysis if funded?) $500,000 present wildlife cells
5. Dikes must withstand stiffwave action/Armoring/Maintenance)
6. Dual Fish and Wildlife Benefits expected from permanent water vegetation expected to succeed and reduce turbidity.
7. Archaeological resources, under dikes
8. For expensive alternative need further study on success potential of restoration.
9. May be plant species that will grow without seed to dike, (bald cypress, Columbia Slough sedge)

Flow Augmentation through Emerald Canal/Amazon Channel

1. Will make city channel maintenance more complex
2. Possibility of spill or runoff contamination greater due to more flow from urban area.
3. Maintaining full pool all summer may be greatest benefit.

Boating Restrictions

1. Need more data to determine if effective, most doubt.
2. Marine Board action required
3. May be able to enforce with volunteers
4. Slow speeds cause bigger waves

Control Bottom Fish (carp, bullhead, sucker)

1. Hard to eliminate because live in all drainage streams. Costly but possible and has been effective elsewhere.
2. Likely to be a significant source of bottom disturbance.
3. Determine impact of fish loss on Ospray/Eagel
4. Economic use and harvest (during winter) may be worth pursuing

Increase Conservation Pool

1. Requires Congressional Action
2. Wildlife Program predicated on 373.5 elev.
3. Increase mosquito problems

Improve Perkins Pt. Beach

1. Relatively inexpensive possible from operating budget.
2. Maintenance Requirements? (silting-probably not major)
3. Probably locally effective

New Park on Long Tom Side

1. Not in cards economically
2. Non game wildlife impacts from Dev. & Boating
3. Shore erosion and water degradation likely to follow development

Bottom Treatment - Large scale sanding - chemical test area - small scale test to determine wind wave/boat wave/fish/swimmer effect.

Incorporative ideas in resource user survey/master plan update.

BK:jt/DJ

MINUTES

AREAWIDE WATER RESOURCE ADVISORY COMMITTEE (AWRAC)
PUBLIC MEETING
Harris Hall, Public Service Building
125 East 8th Street, Eugene, Oregon

No date?

MEMBERS PRESENT:

Laurie Power
Wayne Hite
Rob Skinner, Vice-Chair

OTHERS PRESENT:

Jim Beal

STAFF PRESENT:

Ollie Snowden
Becky Kreag
Barbara Phillips

Meeting opened at 7:40 p.m. Laurie Power chaired the meeting and started with an introduction of the panel, consisting of Wayne Hite; Rob Skinner and herself. She then presented Jim Beal, Fern Ridge Project Manager, Corps of Engineers, to the audience.

She gave a brief history of AWRAC and went on to state the purpose of tonight's meeting -- the release of the results of a year-long study of Fern Ridge water quality in a draft report, Fern Ridge Clean Lake Study. Public comments and questions were invited. She said that the public's suggestions and recommendations would be blended with the draft report and forwarded to the proper bodies for action. Becky Kreag was then introduced as the main speaker.

Becky gave a short narrative on the Fern Ridge study, stating the study was started in March 1981 to find out what water problems exist in Fern Ridge as no prior study had ever been done; for instance, what was the source of muddiness in the lake -- algae, sediments, residues, or a combination of these? A water quality monitoring program was set up and monthly or bimonthly samples of the lake and tributaries were taken. Things being measured were bacteria, different plant nutrients, organic loads that could place demands on the oxygen in the water and the different residues in the water.

Several special studies were completed. A sampling of the algae population took place in summer, 1981. Measurements of chlorophyl were taken to give an idea of amount of algae in water. Productivity measurements and identification of kinds of algae were also completed. An Oregon State soil scientist was hired to determine what kind of solids were in the water, using x-ray analysis. An analysis of the effect of waves on the stirring of the sediment was attempted but failed because the lake remained flat on the two occasions of sampling.

During winter, special surveys of the sediment were done by crossing the reservoir flats and collecting samples of the surface layer and the original soil layer, deeper down. A dredge was used in the deeper areas to collect for samples. The samples were analyzed for settling rates and distribution of particle sizes.

There are 275 square miles draining into the reservoir, an equal amount from Long Tom River, Coyote Basin and a small area which drains Eugene. An inventory of the soils and geology of the region showed that the Coyote Basin had the highest potential for bringing in silt. However, the sediments survey showed that the southeast section of Fern Ridge consists of native clays. The sediments on the top are the weathered, loosened clays. Underneath are the tightly bound clays. Thus, the clays continually feed the lake. Instead of sediments from the rivers accumulating on the flat, shallow areas, the natural clays are being worn away. River sediment is deposited in the deeper areas and contains silt which is heavier than the clay.

Water quality findings demonstrated that there are generally no bacteria in the lake; and if bacteria counts near beaches are high, it is due to contamination from the park. However, Coyote Creek and Amazon Channel often had high bacteria counts. During winter, in-wash causes very high bacteria counts throughout the lake. There is a moderate level of algae growth in the lake. Nitrogen and phosphorous are the primary plant nutrients. During winter, many nutrients are brought in, but most wash through the reservoir. In summer, most nutrients are taken up by plants, especially in marshlands, which keeps algae level low. One problem is that Fern Ridge has low amount of nitrogen compared with phosphorous. A few species (blue-green algae) overcome this by being able to use the nitrogen in the air, but they can also produce obnoxious odors. When more clays are cleared out of the water, more algae growth is likely; but excessive levels are not expected.

Becky showed bottled samples of sediments which had been settling in the water from less than one day to five months. The samples were taken from the end of the reservoir near Perkins Peninsula. One sample contained 1/10 of 1 percent of calcium chloride (salt). Another sample contained 1/10 of 1 percent of alum, a chemical used in water treatment. Both bottles cleared up sediment quite well. Changing chemistry of water would help settle clays.

One other possible problem is the slight accumulation of lead in the main pool area. There were 35 micrograms/liter of lead found in the deep water. Levels of 50 micrograms/liter can be harmful to young fish. Most of the lead is washed off the streets from car fumes and comes through the Amazon Channel.

Restoration measures were aimed primarily at keeping the clay from getting into the water column. The following measures were proposed to reduce the amount of clay stirred up by the wind, motorboats, swimmers or bottom foraging fish. Examples included:

- Dike off the areas that produce most of the clay turbidity to keep it from circulating into the rest of the reservoir.

- Put a chemical treatment or sand on the bottom, which would probably be expensive because enough chemicals would be needed to cover five square miles.

- Dredge out large areas so that the effect of wave action would be minimized. However, the clays are six to ten feet deep, which would cause great expense, and it would be hard to get rid of the dredged clay.

- Use the Emerald Canal to hook up the Willamette River through Eugene with the Amazon Channel and then into Fern Ridge. Thus, the Corps of Engineers could fill the reservoir to its maximum level for the entire summer, making the lake less susceptible to wave action.

A man residing near Fern Ridge had called Becky to comment he had observed that three to four days of strong winds made the entire reservoir turbid. He felt that concentrated restoration measures should not be just on the southeast area.

Laurie Power opened the floor for comments and questions.

Pat Sharp Tri-Pass Ski Club	My club uses the Amazon Canal for a practice site. Is the lead washing out all year long or is the content high only in the winter?
Becky Kreag	It was never found in the bay area where water skiing takes place. The highest levels seem to be in winter flow and would tend to drop out with the sediments in the pool. Urban runoff studies do show levels in the Amazon Channel, above the reservoir, which are consistently higher than they should be.
Pat Sharp	Regarding chemical treatment, would this be a continuous process? How long does a treatment last?
Becky Kreag	It would have to be tested to find out how it worked in the reservoir. It would be best if treating the shallow areas were enough, but it would probably circulate out to the deeper waters. It would be fairly expensive to treat the entire reservoir at the levels required. The treatment would probably have to be done annually. However, testing may show it could be applied onto the sediment directly during the winter when the reservoir is down; possibly, the treatment would be good for one to two years.
Pat Sharp	Would the open dikes be above or below the water?
Becky Kreag	That depends on how the public feels about it. If the dikes are under two to three feet of water, they would still restrict the water circulation. However, it might be a navigation hazard to have them below water.
Pat Sharp	Would the dikes be boulders or dredgings with plant life on them?
Becky Kreag	That has not been decided. Do you have any suggestions as to what the dikes should be?

Pat Sharp	From a water skiing standpoint, I would like to see the open dikes there and above the water. They would make a tremendous wave break. Construction should consist of something that would stop the waves altogether rather than cause them to bounce back.
Ed Stout Triton Yacht Club	Please explain the dike principle and why the sediment doesn't just mix with the current from Coyote Creek and Emerald and just go on out.
Becky Kreag	During the summer, when the reservoir is full, it contains 100,000 acre-feet of water. The waters coming in from Coyote Creek and Amazon Creek often total only 1/2 acre-foot/day. There is very little current or push from these rivers toward the dam, so the dikes would contain water with little exchange. It is wind or boat waves rather than river currents that presently make the sediments circulate. If you physically cut the clay-producing water off from the rest of the lake, very little of it would move out of the narrow passage there.
Lloyd Lindley Triton Yacht Club	How would chemical treatment affect the algae growth? If alum clears the water of clay, wouldn't there be more algae growth and the problem be compounded?
Becky Kreag	Alum is more commonly used in lakes to bind up nutrients and settle the clays. It removes phosphorous. Some small lakes in Washington which had algae problems have been treated with alum successfully. So alum, in particular, would clear up both clay and algae.
Lloyd Lindley	Is there any consideration being given to dredging to deepening the lake and eliminating some of the clay surface in general? Dredging and using the spoils to build up islands around Gibson Island could also make better moorage and overnight anchorage for sailboats, away from the wind. There would be better access for sailboats if the water level was several feet deeper.
Becky Kreag	That may be an option that could be added in as a measure with multiple benefits, the same way Emerald Canal is being considered. Some kind of dredging in the shallow area would have water quality, as well as, boating benefits. However, the benefits would probably primarily be for boating north of Gibson Island because the bottom is sandier. A combination of diking, south of Gibson Island, and building dikes by dredging out of the deep side might have boating values.

Lloyd Lindley	That wouldn't help because the new deep area would be subject to waves. But I also support having the dikes above the water.
Gail Bulen	Why is turbidity such a problem?
Becky Kreag	It's not an earthshaking health problem, but it is disturbing to swim in water where you can't see a foot or two below the surface. It is unpleasant, a safety problem for lifeguarding and may be a problem for some fish. The deeper areas were usually clear to over three feet. In the shallow areas, no areas measured above three feet in visibility. At least three to four feet of clarity would be desirable.
Marie Street	What would the effect of carp and sucker reduction be on osprey?
Becky Kreag	A learned guess from the Fish and Wildlife Department is that if the carp and suckers are reduced, the populations of bass and crappie will increase; the total fish population would not decrease very much. The birds feeding on them would catch whatever kind of fish was available. But the effect on birds of getting rid of fish is something to be considered.
Pat Sharp	Was I correct in understanding that the residue doesn't migrate horizontally, as well as vertically? It stays pretty much in the area that it came from.
Becky Kreag	What we found was that turbidity was greatest in the southeast and least in the Long Tom and the deep area.
Lloyd Lindley	How about the combined use of calcium to fix the sedimentation and riprap to stabilize the barren banks?
Becky Kreag	First, it now looks like calcium may not be an effective stabilizer, sand may be needed. There were not that many areas eroding around Fern Ridge which did not already have some kind of built up banks. Only two or three parks which have not been fully developed have much erosion, such as Zumwalt Park and Shore Acres. Riprap is not one of the major alternatives being considered because the shore erosion is a minor source compared with the bottom clay. But riprap may be needed in some areas because heavy use precludes protection from vegetation. I didn't understand the first part of your question with the calcium.
Lloyd Lindley	If the most affected area is by Perkins, maybe it would be good enough just to treat that area. If the calcium would stay in one area or if that area was blocked off, maybe you could reduce the amount of treatment.

Becky Kreag	That's a good suggestion. Rather than calcium, consideration has been given to digging out some clay, replacing it with sand, building a nice beach, placing some kind of booms around the swim area to cut down waves and doing occasional small treatments in this area.
Ed Stout	Since Perkins, Zumwalt and Shore Acres are in the area with the most turbidity, it seems it would be less expensive to let the swimmers go to the west side than to cut down the wave action or do square miles of treatment.
Becky Kreag	There is a lot of sand rather than clay on the west side which would be good for a beach.
Laurie Power	Jim Beal, has the Corps looked at that point?
Jim Beal	No. We have developed some areas; i.e., Perkins, as free access by the public, as required be federal law.
Lloyd Lindley	Do you provide free moorages?

Laurie Power stated that written comments will be accepted through September 17th.

Laurie Power	What is the time frame for the final report?
Becky Kreag	A draft final report will be prepared by mid-October, and the Advisory Committee will have some data by the first week of October. The recommendations, etc., of the public will be included in the final report, which will be ready in November and given to DEQ, EPA, Corps of Engineers, Fish and Wildlife Marine Board, County and City, as they might all be involved. Specific recommendations may or may not be keyed in on. Instead, there may be listed priority of different restoration measures. Some of these measures would require further study to determine how they should be built and incorporated with other uses of the reservoir and whether they are legal within the Corps' framework.
Bud Thompson Izaac Walton League	Will the Corps have the final say about what measures would be used?
Becky Kreag	Anything within the reservoir itself. There are a couple of measures that would work on Amazon Channel and Coyote Creek waters. Anything done in the reservoir would have to be done at least cooperatively with the Corps. There may be other agencies involved as well.
Bud Thompson	Would the Corps be the primary source for funding?

Becky Kreag	That also would probably be cooperative. The Corps may decide it has an obligation toward ensuring the water quality in the reservoir meets a minimum standard and commit some money toward achieving that goal. Some of the more expensive measures which have benefits other than improved water quality might receive funding from Fish and Wildlife, for example. Perhaps there would be a fee arrangement set up to do certain kinds of bottom treatment and improvements. However, most would likely at least require approval from the Corps. I received a preliminary indication from the Corps regarding the beach treatment suggestion, which would be a low expense, that it could be scheduled in the Corps' operating budget. Public support would probably help influence that.
Bud Thompson	It seems to me that there is a very minimal chance of that happening because the Corps is operating legally under flood control and irrigation. Although it might be nice, I don't see how the Corps is going to justify dredging it three feet deeper for sailboats.
Jim Beal	No, we won't.
Bud Thompson	A lot of these ideas are extremely expensive. Who is going to pay for it?
Becky Kreag	Yes, for example, Fish and Wildlife estimated that scheduled dikes that would grow grain for waterfowl will cost $500,000. To enclose an equal area within the reservoir would cost at least four times that. One less expensive possibility is the road base at Royal Avenue and the road that goes out Gibson Island, which would only need a small connection to be constructed at a third site in order to dike that area. But this is an example that some funds are available.

The meeting adjourned at 8:35 p.m.

BP/DB

VICTOR ATIYEH
GOVERNOR

State Marine Board
OFFICE OF THE DIRECTOR
3000 MARKET ST. N.E., No. 505, SALEM, OREGON 97310 PHONE 378-8587

September 1, 1982

RECEIVED
SEP 7 - 1982

Becky Kreag, Water Quality Planner
Lane Council of Governments
125 E. Eighth Street
Eugene, OR 97401

RE: Fern Ridge Clean Lakes Study

Dear Becky,

We have reviewed the Fern Ridge Study and offer the following comments:

--Turbidity is identified as the primary water quality problem at the lake. A variety of causes are suggested, including swimmers, fish, wind, and boat wakes; however, there is no indication of which of these are responsible for most of the problem. It is difficult to evaluate the proposed actions in the absence of this information.

--Speed regulations are proposed for a large area on the south shore. Further study on the impact of boats at various depths is suggested, and we believe this is appropriate. However, this office does not have funding to carry out such a study.

--The speed zone suggested on Map 2 would be difficult to identify in rule language, and costly to buoy in order to obtain boater compliance. Enforcement would be impossible in the absence of marking. We would want to work closely with Lane County, boating clubs, and the Corps to develop boundaries if a speed zone is to be implemented.

--We have a concern if the structural alternative of diking is to be implemented. The study recognizes the need to mark these dikes with navigation aids. The responsibility for marking it and maintaining these aids to navigation needs to be clarified. Would the Corps accept this responsibility? If not, would Lane County?

We appreciate the opportunity to comment on this report. If the county and Corps of Engineers agree that speed zoning is necessary to protect water quality we will work with both groups in an effort to arrive at a reasonable solution.

Please keep this office advised as to the result of your September 8th meeting.

Sincerely,

Mal McMinn

Mal McMinn
Director

MM:ja
cc: Loraine McKenzie

P. O. Box 887
Eugene, OR 97440
September 16, 1982

RECEIVED SEP 20 1982

Lane Council of Governments
Fern Ridge Study
125 East 8th Ave.
Eugene, OR 97401

As a member of the Emerald Valley Tournament Water Ski Club I was very interested in the findings of the investigation of the water quality and pollution in Fern Ridge Lake. Because we ski from March to October I was concerned about the pollution and bacteria levels. We have a practice area in the Amazon Channel which we use until the late summer when the water gets too shallow. The report helped to reduce my fear that we are skiing in an ares that is a serious health threat. Because the Amazon Channel drains the Eugene area I'm sure that it never will be 100% uncontaminated.

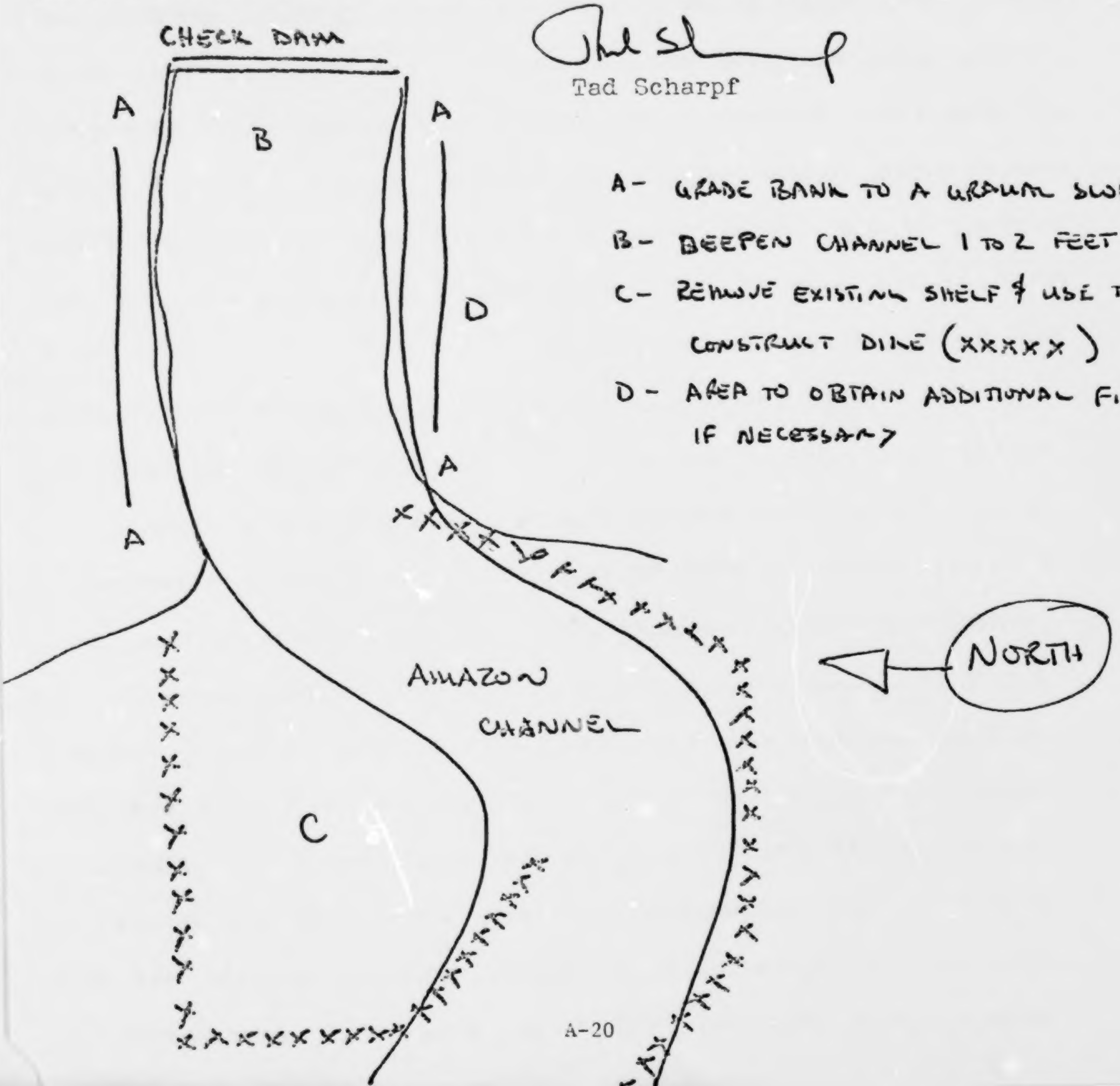
Although I'm not sure what can be done to eliminate the potential health risk, I do have some ideas for trying to clear up the water in the lake. The east-west banks from the check dam for about 1500-2000 feet toward the lake are nearly vertical. By grading them back to a gradual 1:6 to 1:8 slope the waves would not erode them. Planting grass would then help stablize them. This is shown on the map as "A".

A larger undertaking would be to lower the channel bottom 2 feet right below the check dam to 1 foot 700 feet toward the lake and comming level with the current bottom over the next 900 feet. This would require removing about 11 thousand cubic yards. It would make the present depth about 5 feet.

If containment by dikes is under consideration, a small dike system could be built using the material from the channel bottom. Additional material could be obtained from area "C" on the map. This currently is a shelf area about 2½ feet under the surface of the lake. It would contribute a little more than 9 thousned cubic yards of fill. If more is needed it could be removed from area "D" leaving enough shore or dike at the west end to stop wind generated waves from the west. The overlapping of the two dikes at the entrance would also help to stop this wave action. This small dike system would allow study to see how effective a dike system would be in improving water clarity and also give some indication as to the feasability of using native materials. It could be that the west side will need to be ripraped to prevent storm driven wave damage. Again planting grass would help stabize the sides.

It may be possible that by a user fee at tournaments held there or in a lease arrangement our club could help finance part of the cost. I doubt that such a sum could exceed $1000/year. If there are any questions please give me a call at 342-1261 during the day.

Tad Scharpf



A- GRADE BANK TO A GRADUAL SLOPE
B- DEEPEN CHANNEL 1 TO 2 FEET
C- REMOVE EXISTING SHELF & USE TO CONSTRUCT DIKE (XXXXX)
D- AREA TO OBTAIN ADDITIONAL FILL IF NECESSARY

1140 W. 24TH AVE.
EUGENE, OREGON 97405

DEAR COMMITTEE MEMBERS,

I. AM AN ACTIVE, LOCAL BIRDER (BIRD-WATCHER) WIT SEVERAL COMMENTS TO MAKE REGARDING PROPOSED IMPROVEMENTS IN THE FERN RIDGE CLEAN LAKES STUDY AS THEY MAY RELAT TO BIRDS AND BIRD HABITATS.

FERN RIDGE RESERVOIR AND VICINITY REPRESENTS, WITHOUT DOUBT, THE MOST DIVERSE AND VALUABLE BIRDING OPPORTUNITIES IN THE EUGENE-SPRINGFIELD AREA. THE VARIETY AND QUALITY OF HABITATS PROVIDE LIFE NEEDS FOR MORE THAN 225 SPECIE WHICH HAVE BEEN OBSERVED THERE. ALONG WITH WILLIAM L FINLEY N.W.R. AND SAUVIES ISLAND S.W.M.A., FERN RIDGE REPRESENTS ONE OF THE THREE BEST BIRDING LOCATIONS IN WESTERN, INTERIOR OREGON.

THE MOST CRITICAL HABITAT AT FERN RIDGE IS THE MARSH AND WET GRASSLANDS IN THE SOUTHEAST SECTOR. MANY RARE BIRD SIGHTINGS HAVE BEEN MADE HERE (LEAST BITTERN, RED-SHOULDERED HAWK, SWAMP SPARROW, CHESTNUT-COLLARED LONGSPUR, ETC.). SEVERAL SPECIES OF CRITICAL CONCERN HAVE ALSO BEEN OBSERVED USING MARSH AND WETLAND HABITATS (AMERICAN BITTERN, MARSH HAWK, WHITE-TAILED KITE, PEREGRINE FALCON, SORA, VIRGINIA RAIL, MARSH WREN, SHORT-EARED OWL, ETC.). OF EQUAL VALUE IS THE IMPORTANCE OF THE WETLANDS TO A WIDE VARIETY OF GAME AND NONGAME SPECIES WHICH USE THIS AREA FOR NESTING, RESTING, FEEDING, AND COVER.

THE PROPOSED DIKES COULD BE BENEFICIAL TO BIRD HABITAT, IF MANAGED TO OPTIMIZE HABITAT FOR TOTAL SPECIES—NOT JUST GAME SPECIES.

BY ENCLOSING THE MARSH AREA FROM PERKINS PENINSULA TO GIBSON ISLAND AND BY EXTENDING THE DIKE ACROSS TO SHORE ACRES, THE FOLLOWING BIRD HABITAT IMPROVEMENTS COULD BE ACHIEVED:

1) WATER LEVELS IN THE MARSH COULD BE CONTROLLED BETTER DURING THE NESTING, MIGRATION, AND WINTER SEASONS TO IMPROVE BIRD HABITAT

2) THE DIKES COULD PROVIDE ACCESS (FOOT TRAILS FOR HUNTERS, BIRDERS, SCHOOL GROUPS AND OTHERS) AROUND THE PERIPHERY OF THE MARSH.

3) CELLS CREATED BY THE DIKES COULD BE USED FOR IRRIGATION AND FLOOD CONTROLL WITHOUT DETRACTING FROM OTHER RESERVOIR USES.

4) SOME CELLS COULD BE DRAINED EARLY IN THE SUMMER TO PROVIDE MUDFLATS FOR MIGRATING SHOREBIRDS. CURRENT MANAGEMENT OF FULL POOL UNTIL EARLY OCTOBER ELIMINATES THIS CRITICAL HABITAT DURING THE JULY - OCTOBER SHOREBIRD MIGRATION SEASON. IN THE DROUGHT OF 1977, PHENOMINAL SHOREBIRD OBSERVATIONS WERE RECORDED AT FERN RIDGE, DRAWING BIRDERS FROM OTHER PLACES IN OREGON TO SEE SUCH BIRDS AS SEMIPALMATED PLOVER, AMERICAN GOLDEN PLOVER, LESSER YELLOW LEGS, PECTORAL SANDPIPER, BAIRD'S SANDPIPER, SHORT-BILLED DOWITCHER, STILT SANDPIPER, AND AMERICAN AVOCET.

DIKES, CREATING CELLS SERVED BY CANALS AND A SYSTEM OF GATES AND PUMPS, COULD BE BUILT INTO A WILDLIFE MANAGEMENT AREA WHICH COULD ELEVATE FERN RIDGE'S STATUS AS ONE OF THE STATE'S PREMIER BIRDING AREAS.

USE CONFLICTS WOULD STILL BE A PROBLEM. WHAT IS GOOD FOR PEOPLE IS NOT ALWAYS GOOD FOR WILDLIFE AND CONFLICTS AMONG HUMAN USER GROUPS ARE NOT EASY TO RESOLVE. THE WATER QUALITY BENEFITS RECOMMENDED COULD BE OF TREMENDOUS WILDLIFE BENEFIT, IF MANAGED PROPERLY.

THANK YOU,

Steven C.

lcog Lane Council of Governments
NORTH PLAZA LEVEL PSB / 125 EAST EIGHTH AVENUE / EUGENE, OREGON 97401 / TELEPHONE (503) 687-4283

MEMORANDUM

September 3, 1982

TO: FERN RIDGE PUBLIC INVOLVEMENT FILE

FROM: Becky Kreag

SUBJECT: Comments by Lloyd Lindley, Triton Yacht Club on Fern Ridge Restoration

Mr. Lindley called 8/23/82 in response to the R.G. news article on Fern Ridge. Said Triton Yacht Club has talked for years with the Corps about deepening the reservoir to improve boating, and reservoir storage capacity and get rid of stump areas. Sail boats should have a 7 foot depth for good passage and as the reservoir drops large areas become inaccessible. He believed that if the shallows were deepened to more than 20 feet, like at the dam, the water would be clearer. He said the area south of West 11th Ave. and the Long Tom delta should be preserved for wildlife, but areas such as Amazon, Coyote and Perkins Bays should be deepened. He sited an example of reservoir deepening where the sediments were sold to help recover costs. I told him the sediments we found were pure clay - several feet in depth and probably not desirable for soil. He suggested that an alternative would be to create or build upon existing islands or rip-rapping shores. He thought a user fee could be assessed to pay for dredging and people would be willing to pay if facilities were good.

He has a conflict September 8, 1982 and can not attend the meeting. I sent him the pamphlet.

Mr. Lindley called 9/9/82 following the meeting to suggest that the Soil Conservation Service be investigated as a sponsor for Fern Ridge enhancement measures. He noted they were involved in recreational development for the South Beach Marina in Yaquina Bay. He also suggested that we investigate constructing a series of islands rather than a solid dike for Amazon Bay, and that the shallow areas be dredged to provide needed fill. This would also increase flood storage capacity.

Mr. Lindley called again on 9/10/82 to suggest that upstream storage reservoirs be considered to augment flow and reservoir level in the summer. I told him this had been considered but dropped because of lack of appropriate sites and sponsors. He was also concerned that care be taken in experimenting with new vegetation to avoid excessive growth problems.

BK:bp/DB

LCOG Lane Council of Governments
NORTH PLAZA LEVEL PSB / 125 EAST EIGHTH AVENUE / EUGENE, OREGON 97401 / TELEPHONE (503) 687-4283

MEMORANDUM

September 9, 1982

TO: Fern Ridge Public Involvement File

FROM: Becky Kreag

SUBJECT: Comments by Darrell Linker on Findings

Darrell Linker, 87751 Erdman Way, Veneta, Oregon 97487 called on September 8, 1982 with comments on Fern Ridge Finding. He lives overlooking Fern Ridge and has observed over the last few years that any time there are 2-3 days of strong winds from north or northwest the entire lake gets churned up. It appears to him that muddy water flowed in from the northwest and that if we concentrated controls on the southeast corner we would be missing much of the source.

His impression is based partly on the misconception that the water is flowing in the direction of the waves. In fact, the individual water molecules are sent into circular motion which brings them back to nearly their original position once each wave passes. It is possible that waves are strong enough to stir up sediments from some of the deeper waters. I told him that our settling tests showed that anything stirred up from the deeper water would settle again in a few days while clay stirred up in the shallow would remain in the water for months.

He felt that was a valid point and said he was happy that someone was concerned enough to look into ways to clean up Fern Ridge, granting that it would never be a Crater Lake. He added that the diking idea would be good for ducks too; that Perkins beach could really use some improvements and that we should be caution about introducing aquatic plants to make sure they wouldn't get out of hand like at Silt-Coos Lake, but added that the existing shore vegetation definitely helps keep those shallow area clear.

He learned of the Study through the paper and I sent him a copy of Preliminary Findings and Proposals.

BK:jt/DJ

lcog Lane Council of Governments
NORTH PLAZA LEVEL PSB / 125 EAST EIGHTH AVENUE / EUGENE, OREGON 97401 / TELEPHONE (503) 687-4283

MEMORANDUM

September 27, 1982

TO: Fern Ridge Public Involvement File

FROM: Becky Kreag

SUBJECT: Comments by Chuck Buchholz on Restoration

Mr. Buchholz's family lives on the west side of Fern Ridge in the area labeled "NEW PARK". He said that all of the land owners on the west side were long time residents, many predating the Reservoir. He said as land owners he doubted that any would willingly sell their property for park use and expressed concern about traffic, vandals, litter and trespass. Any new park development would doubtlessly require condemnation. He distributed the "Preliminary Results" report to the people living there but I received no additional comments from them.

BK:jt/DJ

APPENDIX B

CLEAN LAKES PROGRAM
Lane Council of Governments, Eugene, Oregon

TESTING PROCEDURES, ACCURACIES AND PRECISIONS
Lane County Environmental Health Water Laboratory

TEST	METHOD	Std. Method PRECISION Statement	Estimated Lab. PRECISION of Duplicates	Estimated ACCURACY vs. EPA Standards
Alkalinity	Methylorange	± 3-5%	Greatest of ± 1.5% or ± 1 mg/L	± 3%
Ammonia	Selecton electroide (Orior)	± 2% (manufacturer) ± 4-40% (EPA)	Greatest of ± 0.1 mg/L or ± 3%	Greatest of ± 4% or ± 0.1 mg/L
B.O.D.	Alkaline Azide	± 10-15% for sewage	± 1 mg for storm water	Not applicable
D.O.		±.1	±1	
Chloride	Diphenylcarbazone	± 3.3% ± 1% or ± 0.5 mg/L	Greatest of ± 1.5% or ± 0.7 mg/L	
Coliform Bacteria (fecal) (total)	Membrane filter (m FC)		Greatest of ± 20% or ± 15/100 ml	NO WAY TO DETERMINE
C.O.D.	Dichromate/ H_2SO_4 Digestion	± 8%	Greatest of ± 1.5% or ± 0.5 mg/L	Greatest of ± 3% or ± 1 mg/L
Hardness	EDTA	± 2.-3%	Greatest of ± 1% or ± 1 mg/L	± 3.5%
Herbicides	EPA method for Organochlorine Pesticides & Chlorophenoxy Herbicides (Varian 1860 - electroncapture)		2,4-D- ± .1 mg/L	± 0.1 ug/L

TEST	METHOD	Std. Method PRECISION Statement	Estimated Lab. PRECISION of Duplicates	Estimated ACCURACY vs. EPA Standards
METALS		EPA SPECIFICATIONS	SENSITIVITY	
Pb	IL-551 w/555 furnace		10 ug/L	± 10%
Fe (flame)			200 ug/L	ditto
As			10 ug/L	ditto
Nitrate	Cadmium Rduction	± 6% @ 0.5 mg/L ± 1% @ 5.0 mg/L	± 1.4%	± 3%
Nitrite		SEE NITRATE		
pH	Meter (Electrovolt)	± 0.1 unit	± 0.1 unit	± 0.2 unit
Phosphate	Ammonium molybdate digestion	- 2 to ± 6% bias	Greatest of ± 2% or ± .002 mg/L	Greatest of ± 4% or ± .003 mg/L
Orthophosphate	Ascorbic acid		± 5%	
Residue Total	Gravimetric	Greatest of ± 4 mg/L or ± 5%	Greatest of ± 2% or ± 1 mg/L	NO WAY TO DETERMINE
Residue Non-Filterable	Gravimetric	± 30% low range ± 8% high range ± 2%	Greatest of ± 0.5 mg/L or	NO WAY DETERMINE
Settleable Solids	Imhoff Cone	Not applicable	± 0.1 ml/L	NA
Sulfate	Barium precipitate	±9%	Greatest of ±3% or ± 0.2 mg/L	Greatest of ±4% or ± 0.3 mg/L
Turbidity	Nephelometric (HACH)	Manufactures Specs. ± 2% full scale	Same	Same
Chlorophyll-a	Spectrophotometric Monochromatic, corrected		± 0.07 mg/l	
Gross Primary Productivity	Oxygen Evolution (Light-Dark Bottle)		.5 mg/l for averaged duplicate D.O.s	

Appendix C

MONITORING DATA AND STATISTICAL SUMMARIES

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     STATION HEADING                                                                      PDP STORET -- 02-NOV-82                      PAGE    4
                                                                                          ENVIRONMENTAL SERVICES DIVISION
      314LCUGU04        FR-AB                                                             EPA REGION 10 -- SEATTLE
     FERN RIDGE RESERVOIR IN "AMAZON BAY"                                                 INVENTORY OF LANE DATA
     44 05 22.0 123 15 35.0  2           ALT=     0FT
     41039 OREGON        PACIFIC NORTHWEST
     WILLAMETTE RIVER                            1309
     21ORMISC  REACH=                DRG AREA=      0 SQ MI
     RESERV/AMBNT

  SUMMARY OF ALL PARAMETERS FROM   /  /    TO 99/99/99
                                             #OBS  #OBS                                                                     BEGIN        END
     PAR# PARAMETER NAME           UNITS     TOTL  USED        MEAN      STD DEV      MINIMUM     MAXIMUM     PERIOD       PERIOD
   ------ ------------------ ---------       ----  ----   ---------    ---------    ---------   ---------    --------    --------
    00010     WATER     TEMP      CENT         16    16        18.2          4.2         10.5        23.5    81/03/23    82/06/23
    00062     WATER SURF ELE   IN FEET         16    16       372.5          1.6        367.5       373.6    81/03/23    82/06/23
    00076      TURB TRBIDMTR  HACH FTU         16    16        13.3          7.2          5.0        30.0    81/03/23    82/06/23
    00077    TRANSP   SECCHI    INCHES         15    15        24.5          7.4         12.0        37.0    81/03/23    82/06/23
    00095 CNDUCTVY    AT 25C  MICROMHO         11    11        62.5          8.3         52.0        73.0    81/03/23    82/06/23
    00300         DO              MG/L         15    15         9.0          0.7          8.0        10.4    81/04/20    82/06/23
    00320        BOD ULT FRST     MG/L          9     9         3.0          0.7          1.8         3.9    81/05/19    82/06/23
    00335        COD LOWLEVEL     MG/L         12    12        10.0          1.8          7.7        13.0    81/03/23    82/06/23
    00400         PH                SU          9     9        7.04         0.28         6.70        7.60    81/03/23    82/04/19
    00410      T ALK     CACO3    MG/L         10    10        19.8          1.6         16.9        22.1    81/03/23    82/04/19
    00500   RESIDUE     TOTAL     MG/L         15    15        64.5         14.7         40.0        87.0    81/04/20    82/06/23
    00530   RESIDUE TOT NFLT      MG/L         15    15        19.6         11.0          6.0        54.0    81/04/20    82/06/23
    00545   RESIDUE SETTLBLE      ML/L          7     0         0.0          0.0          0.0         0.1    81/06/22    82/04/19
    00610 NH3+NH4-   N TOTAL      MG/L         10     0       0.000        0.000        0.010       0.100    81/03/23    82/04/19
    00630   NO2&NO3  N-TOTAL      MG/L         16    14        0.03         0.02         0.01        0.07    81/03/23    82/06/23
    00665 PHOS-TOT              MG/L P         12    12       0.049        0.019        0.028       0.083    81/03/23    82/06/23
    00900 TOT HARD     CACO3      MG/L         12    12        19.3          2.1         16.0        23.2    81/03/23    82/06/23
    00940 CHLORIDE        CL      MG/L         10    10         5.5          1.0          3.7         7.0    81/03/23    82/04/19
    00945  SULFATE  SO4-TOT       MG/L          3     1         1.0          0.0          1.0         1.0    81/03/23    81/05/19
    01002  ARSENIC    AS,TOT      UG/L         11     0         0.0          0.0         10.0        10.0    81/03/23    82/04/19
    01045       IRON  FE,TOT      UG/L         11    11       526.4        239.5        190.0       960.0    81/03/23    82/04/19
    01051       LEAD  PB,TOT      UG/L         11     6         0.7          0.7          0.0         5.0    81/03/23    82/04/19
    31501 TOT COLI MFIMENDO  /100ML LG         11     9        50.3          2.8          8.0       200.0    81/03/23    82/06/23
    31616 FEC COLI MFM-FCBR  /100ML LG         11     6        28.5          2.4          5.0       100.0    81/03/23    82/06/23
    32211 CHLRPHYL  A UG/L CORRECTD             9     8        0.77         0.72         0.04        2.57    81/04/20    81/09/14
    39730    2,4-D WHL SMPL       UG/L          3     0       0.000        0.000        0.100       0.100    81/04/20    81/08/24
    70507    PHOS-T    ORTHO    MG/L P         12    12       0.012        0.008        0.002       0.030    81/05/19    82/04/19
    STATION HEADING                                                     PDP STORET -- 02-NOV-82                  PAGE     6
                                                                        ENVIRONMENTAL SERVICES DIVISION
     314LCOG004       FR-AB                                             EPA REGION 10 -- SEATTLE
    FERN RIDGE RESERVOIR IN "AMAZON BAY"                                SUMMARY OF LANE DATA
    44 05 22.0 123 15 35.0  2           ALT=      0FT
    41039 OREGON       PACIFIC NORTHWEST
    WILLAMETTE RIVER                              1309
    21OREISC   REACH=                 DRG AREA=     0 SQ MI
    RESERV/AMBNT

                                10          62          76          77          95         300         320         335         400         410
    DATE                     WATER       WATER        TURB      TRANSP    CNDUCTVY          DO         BOD         COD          PH       T ALK
    FROM     TIME DEPTH       TEMP    SURF ELE    TRBIDMTR     SECCHI      AT 25C                 ULT FRST    LOWLEVEL                   CACO3
     TO              FEET     CENT     IN FEET    HACH FTU     INCHES    MICROMHO        MG/L        MG/L        MG/L          SU        MG/L
    -------- ---- -----   --------    --------    --------    --------    --------    --------    --------    --------    --------    --------
    81/03/23 1340  002        13.0       370.5        18.0          19          64                                11.0        6.80          17
    81/04/20 1100  002        16.0       373.4        13.0          28                       9.6                  10.6        6.90          19
    81/05/19 1030  002        16.0       373.6        12.0          30          55         9.5         2.9         7.7                      18
    81/06/08 1000  002        17.5       373.6        13.0          24                       9.0
    81/06/22 1045  002        19.0       373.5         9.1          27          66         9.2         2.9         9.0        7.10          19
    81/07/06 1145  002        21.5       373.4         7.2          30                       8.4
    81/07/20 1200  002        21.5       373.1         6.1          30          70         8.3         2.2         8.6        7.00          21
    81/08/05 1120  002        22.0       372.7         7.6          24                       8.0
    81/08/24 1245  002        23.5       372.2        12.0          18          73         8.5         2.7         9.4        7.40          22
    81/09/14 1030  002        21.0       371.7        12.0          19                       8.8
    81/09/28 1050  002        16.5       371.6        15.0          18          72         8.5         1.8        11.5        7.10          22
    81/10/19 1630  002        16.0       367.5        19.0          12          73        10.0                    10.9        7.60          21
    82/04/19 1020  002        10.5       373.1        30.0          15          54        10.2         3.9        13.0        6.70          18
    82/04/19 1030  006        10.5       373.1        28.0                      52        10.4         3.8        13.0        6.80          20
    82/06/23 1200  002        23.0       373.3         5.3          37          54         8.4         3.4         7.8
    82/06/23 1205  002        23.0       373.3         5.0          37          55         8.8         3.4         7.8

                               500         530         545         610         630         665         900         940         945        1002
    DATE                   RESIDUE     RESIDUE     RESIDUE    NH3+NH4-    NO2&NO3     PHOS-TOT    TOT HARD    CHLORIDE     SULFATE     ARSENIC
    FROM     TIME DEPTH      TOTAL    TOT NFLT    SETTLBLE     N TOTAL     N-TOTAL                   CACO3          CL     SO4-TOT      AS,TOT
     TO              FEET     MG/L        MG/L        ML/L        MG/L        MG/L      MG/L P        MG/L        MG/L        MG/L        UG/L
    -------- ---- -----   --------    --------    --------    --------    --------    --------    --------    --------    --------    --------
    81/03/23 1340  002                                         0.100K        0.07       0.054          18           6          1K         10K
    81/04/20 1100  002          82          26                 0.100K        0.02       0.041          20           5           1         10K
    81/05/19 1030  002          87          54                 0.100K        0.02       0.040          19           5          1K         10K
    81/06/08 1000  002          65          20                               0.01
    81/06/22 1045  002          60          12          0K     0.010K       0.01K       0.030          19           6                      10K
    81/07/06 1145  002          58          19                               0.01
    81/07/20 1200  002          51          11          0K     0.010K        0.01       0.028          21           6                      10K
    81/08/05 1120  002          52          15                               0.01
    81/08/24 1245  002          64          16          0K     0.010K        0.01       0.047          23           6                      10K
    81/09/14 1030  002          59          19                               0.01                                                         10K
    81/09/28 1050  002          60          18          0K     0.010K        0.01       0.042          21           6                      10K
    81/10/19 1630  002          82          28          0K     0.010K       0.01K       0.083          22           7                      10K
    82/04/19 1020  002          83          23          0K     0.010K        0.05       0.079          18           4                      10K
    82/04/19 1030  006          81          20          0K     0.010K        0.05       0.074          18           4                      10K
    82/06/23 1200  002          40           7                               0.02       0.032          16
    82/06/23 1205  002          43           6                               0.03       0.035          16

                              1045        1051       31501       31616       37211       39730       70507
    DATE                      IRON        LEAD    TOT COLI    FEC COLI    CHLRPHYL       2,4-D      PHOS-T
    FROM     TIME DEPTH     FE,TOT      PB,TOT    MFIMENDO    MFM-FCBR      A UG/L    WHL SMPL       ORTHO
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STATION:21ORMISC 314LCOG004     FERN RIDGE RESERVOIR IN "AMAZON BAY"                    PDP STORET -- 07-NOV-82              PAGE    7
----------------------------------------------------------------------------------------  SUMMARY OF LAKE DATA

                              1045       1051      31501      31616      37211      39730      70507
  DATE                        IRON       LEAD    TOT COLI   FEC COLI   CHLRPHYL     2,4-D     PHOS-T
  FROM    TIME DEPTH         FE,TOT     PB,TOT   MFIMENDO   MFM-FCBR    A UG/L   WHL SMPL     ORTHO
   TO          FEET           MG/L       UG/L     /100ML     /100ML    CORRECTD      UG/L     MG/L P
-------- ---- -----        --------   --------   --------   --------   --------   --------   --------
81/03/23 1340  002              760         5K        20K        10K
81/04/20 1100  002              480         5K                             0.34     0.100K
81/05/19 1030  002              450         5K         84        10K       0.56                0.010
81/06/08 1000  002                                                         0.04K               0.030
81/06/22 1045  002              400         5K         80         10       0.95                0.010
81/07/06 1145  002                                                         0.32                0.020
81/07/20 1200  002              190         5K        20K         5K       0.23     0.100K     0.005
81/08/05 1120  002                                                         0.45                0.002
81/08/24 1245  002              350          0         20         15       0.70     0.100K     0.006
81/09/14 1030  002              340          0                             2.57                0.006
81/09/28 1050  002              360          1         40         30                           0.025
81/10/19 1630  002              580          1         60         15                           0.012
82/04/19 1020  002              960          0        200         80                           0.008
82/04/19 1030  006              970          7        200        100                           0.008
82/06/23 1200  002                                     20        20K
82/06/23 1205  002                                      8        20K
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STATION HEADING                                                             PDP STORET -- 02-NOV-82              PAGE    5
                                                                            ENVIRONMENTAL SERVICES DIVISION
 314LCUG005       FR-CR                                                     EPA REGION 10 -- SEATTLE
FERN RIDGE RESERVOIR IN "COYOTE BAY"                                        INVENTORY OF LANE DATA
44 03 24.0 123 17 05.0  2            ALT=     0FT
41039 OREGON        PACIFIC NORTHWEST
WILLAMETTE RIVER                             1309
210RMISC  REACH=               DRG AREA=      0 SQ MI
RESERV/AMBNT

SUMMARY OF ALL PARAMETERS FROM   /  /    TO 99/99/99
                                         #OBS  #OBS                                                       BEGIN       END
  PAR# PARAMETER NAME          UNITS     TOTL  USED        MEAN      STD DEV      MINIMUM      MAXIMUM   PERIOD      PERIOD
 ------ ----------------- ---------      ----  ----   ---------    ---------    ---------    ---------  --------    --------
 00010     WATER      TEMP      CENT       16    16        17.2          5.3          8.0         24.5  81/03/23    82/06/23
 00062    WATER SURF ELE   IN FEET         16    16       372.8          0.9        370.5        373.6  81/03/23    82/06/23
 00076     TURB TRBIDMTR HACH FTU          16    16        15.5          7.9          7.3         35.0  81/03/23    82/06/23
 00077   TRANSP    SECCHI   INCHES         14    14        21.8          6.1         10.0         31.0  81/03/23    82/06/23
 00095 CNDUCTVY   AT 25C MICROMHO          11    11        58.9         10.0         46.0         73.0  81/03/23    82/06/23
 00300        DO                MG/L       15    15         9.4          1.1          8.0         11.3  81/04/20    82/06/23
 00320       BOD ULT FRST       MG/L        8     8         3.2          0.6          2.4          4.1  81/05/19    82/06/23
 00335       COD LOWLEVEL       MG/L       12    12        10.1          1.5          7.7         12.4  81/03/23    82/06/23
 00400        PH                  SU       10    10        6.94         0.20         6.70         7.30  81/03/23    82/04/19
 00410     T ALK     CACO3      MG/L       11    11        18.3          2.5         14.6         21.9  81/03/23    82/04/19
 00500   RESIDUE     TOTAL      MG/L       15    15        70.3         17.3         49.0        109.0  81/04/20    82/06/23
 00530   RESIDUE TOT NFLT       MG/L       15    15        23.4         16.0         11.0         59.0  81/04/20    82/06/23
 00545   RESIDUE SETTLBLE       ML/L        8     2         0.0          0.0          0.0          0.1  81/06/22    82/04/19
 00610 NH3+NH4-   N TOTAL       MG/L       11     0       0.000        0.000        0.010        0.100  81/03/23    82/04/19
 00630   NO2&NO3  N-TOTAL       MG/L       16    16        0.03         0.03         0.01         0.11  81/03/23    82/06/23
 00665 PHUS-TOT               MG/L P       12    12       0.048        0.024        0.010        0.094  81/03/23    82/06/23
 00900 TOT HARD    CACO3        MG/L       12    12        18.0          2.8         12.8         22.5  81/03/23    82/06/23
 00940 CHLORIDE       CL        MG/L       11    11         4.9          1.1          3.0          6.2  81/03/23    82/04/19
 00945   SULFATE  SO4-TOT       MG/L        3     1         1.0          0.0          1.0          1.0  81/03/23    81/05/19
 01002   ARSENIC   AS,TOT       UG/L       11     0         0.0          0.0         10.0         10.0  81/03/23    82/04/19
 01045      IRON   FE,TOT       UG/L       11    11       635.5        428.2        220.0       1630.0  81/03/23    82/04/19
 01051      LEAD   PB,TOT       UG/L       11     6         0.8          0.7          0.0          5.0  81/03/23    82/04/19
 31501 TOT COLI MFIMENDO     /100ML LG     12    11        78.5          3.1         13.0        500.0  81/03/23    82/06/23
 31616 FEC COLI MFM-FCBR     /100ML LG     11     7        38.2          5.4          5.0        300.0  81/03/23    82/06/23
 32211 CHLRPHYL   A UG/L CORRECTD           9     9        0.61         0.53         0.12         2.03  81/04/20    81/09/14
 70507    PHOS-T    ORTHO     MG/L P       13    13       0.012        0.010        0.002        0.030  81/05/19    82/04/19
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STATION HEADING                                                            PDP STORET -- 02-NOV-82              PAGE   8
                                                                           ENVIRONMENTAL SERVICES DIVISION
 3141COG005        FP-CB                                                   EPA REGION 10 -- SEATTLE
FERN RIDGE RESERVOIR IN "COYOTE BAY"                                       SUMMARY OF LANE DATA
44 03 24.0 123 17 05.0  2               ALT=        0FT
41039 OREGON           PACIFIC NORTHWEST
WILLAMETTE RIVER                                    1309
21ORMISC  REACH=                   DRG AREA=          0 SQ MI
RESERV/AMBNT

                           10        62        76        77        95       300       320       335       400       410
 DATE                   WATER     WATER      TURB    TRANSP  CNDUCTVY        DO       BOD       COD        PH     T ALK
 FROM    TIME DEPTH      TEMP  SURF ELE  TRBIDNTR    SECCHI    AT 25C            ULT FRST  LOWLEVEL               CACO3
  TO           FEET      CENT   IN FEET  HACH FTU    INCHES  MICROMHO      MG/L      MG/L      MG/L        SU      MG/L
-------- ---- -----  --------  --------  --------  --------  --------  --------  --------  --------  --------  --------
81/03/23 1415  002       13.5     370.5      18.0        19        59                          11.4      6.90        16
81/04/20 1130  002       16.0     373.4      13.0        29                10.6                10.1      6.80        20
81/05/19 1140  002       16.5     373.6      12.0        31        54       9.1       2.8       7.7                  18
81/06/08 1100  002       17.5     373.6      13.0        24                 9.0
81/06/22 1130  002       20.0     373.5       8.5        28        65       9.5       3.4       9.5      7.20        19
81/07/06 1300  002       22.0     373.4       9.5        24                 8.8
81/07/20 1230  002       22.0     373.1       8.2        23        73       8.4       2.7       8.2      7.00        21
81/08/05 1200  002       22.0     372.7      14.5        22                 8.2
81/08/24 1345  002       23.5     372.2      17.0        12        73       8.1       2.4       9.6      7.30        22
81/09/14 1200  002       22.0     371.7      15.0        18                 8.0
81/09/28 1130  002       17.0     371.6      15.0        18        73       8.8       2.8      10.0      7.10        22
82/04/05 1220  001        8.0     373.0      13.0       18J        47      11.1                10.7      6.70        15
82/04/05 1220  005        8.5     373.0      14.0                  46      11.3                11.6      6.70        15
82/04/19 1115  002       10.5     373.1      35.0        10        51      10.3       3.7      12.0      6.80        17
82/04/19 1115  005       11.0     373.1      35.0                  51      10.6       3.9      12.4      6.90        17
82/06/23 1230  002       24.5     373.3       7.3        29        56       9.6       4.1       8.2

                          500       530       545       610       630       665       900       940       945      1002
 DATE                 RESIDUE   RESIDUE   RESIDUE  NH3+NH4-   NO2&NO3  PHOS-TOT  TOT HARD  CHLORIDE   SULFATE   ARSENIC
 FROM    TIME DEPTH     TOTAL  TOT NFLT  SETTLBLE   N TOTAL   N-TOTAL               CACO3        CL   SO4-TOT    AS,TOT
  TO           FEET      MG/L      MG/L      ML/L      MG/L      MG/L    MG/L P      MG/L      MG/L      MG/L      UG/L
-------- ---- -----  --------  --------  --------  --------  --------  --------  --------  --------  --------  --------
81/03/23 1415  002                                   0.100K      0.11     0.049        17         5        1K       10K
81/04/20 1130  002         82        27              0.100K      0.05     0.010        20         6         1       10K
81/05/19 1140  002         81        45              0.100K      0.01     0.040        19         5        1K       10K
81/06/08 1100  002         64        16                          0.02
81/06/22 1130  002         57        13        0K    0.010K      0.01     0.030        20         6                  10K
81/07/06 1300  002         64        14                          0.01
81/07/20 1230  002         55        11        0K    0.010K      0.01     0.030        21         6                  10K
81/08/05 1200  002         63        20                          0.01
81/08/24 1345  002         73        18        0K    0.010K      0.01     0.064        23         6                  10K
81/09/14 1200  002         62        17                          0.02
81/09/28 1130  002         69        18        0K    0.010K      0.01     0.043        21         6                  10K
82/04/05 1220  001         61        12        0K    0.010K      0.02     0.050        13         4                  10K
82/04/05 1220  005         58        12        0K    0.010K      0.01     0.047        13         3                  10K
82/04/19 1115  002        109        58         0    0.010K      0.06     0.094        17         4                  10K
82/04/19 1115  005        108        59         0    0.010K      0.06     0.091        17         4                  10K
82/06/23 1230  002         49        12                          0.02     0.029        17

                         1045      1051     31501     71616     32211     70507
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                                 1045        1051     31501     31616     32211      70507
  DATE                           IRON        LEAD   TOT COLI  FEC COLI  CHLRPHYL    PHUS-T
  FROM    TIME DEPTH           FE,TOT      PB,TOT   MFIMENDO  MFM-FCBR   A UG/L     ORTHO
   TO           FEET             UG/L        UG/L    /100ML    /100ML   CORRECTD    MG/L P
-------- ---- -----         --------    --------  --------  --------  --------  --------
81/03/23 1415  002               700          5K        60        10
81/04/20 1130  002               590          5K       310                0,45
81/05/19 1140  002               450          5K        80       10K      0,41     0,010
81/06/08 1100  002                                                        0,45     0,030
81/06/22 1130  002               390          5K        70       10K      0,81     0,010
81/07/06 1300  002                                                        0,32     0,030
81/07/20 1230  002               220          5K       20K        5K      0,12     0,007
81/08/05 1200  002                                                        0,39     0,002
81/08/24 1345  002               490           1        60         5      0,53     0,011
81/09/14 1200  002                                                        2,03     0,004
81/09/28 1130  002               420           1        70         5               0,026
82/04/05 1220  001               340           0       100        40               0,003
82/04/05 1220  005               390           0      100J       180               0,003
82/04/19 1115  002              1370           1       500       220               0,012
82/04/19 1115  005              1630           2       300       300               0,013
82/06/23 1230  002                                      13       20K
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                                                                    PDP STORET -- 02-NOV-82                   PAGE    9
 STATION HEADING                                                    ENVIRONMENTAL SERVICES DIVISION
                                                                    EPA REGION 10 -- SEATTLE
  3141COG009        FR-PR                                           INVENTORY OF LAKE DATA
 FERN RIDGE RESERVOIR TO "PERKINS BAY"
 44 03 24.0 123 15 11.0  2            ALT=    0FT
 41039 OREGON        PACIFIC NORTHWEST
 WILLAMETTE RIVER                               1309
 210PMISC  REACH=                 DRG AREA=      0 SQ MI
 RESERV/AMBNT

SUMMARY OF ALL PARAMETERS FROM   /  /   TO 99/99/99                                                            BEGIN        END
                                         #OBS  #OBS                                                                 PERIOD       PERIOD
  PAR# PARAMETER NAME        UNITS       TOTL  USED      MEAN      STD DEV     MINIMUM      MAXIMUM     PERIOD       PERIOD
 ------ ------------------ ---------     ----  ----  ---------  ---------   ---------    ---------   --------     --------
 00010     WATER      TEMP      CENT      15    15        18.0        4.8         9.0        25.0    81/04/20     82/06/23
 00062     WATER SURF ELE   IN FEET      15    15       372.9        0.7       371.6       373.6    81/04/20     82/06/23
 00076      TURB TRBIDMTR  HACH FTU      15    15        13.8        9.1         4.8        36.0    81/04/20     82/06/23
 00077    TRANSP    SECCHI    INCHES     12    12        26.8       11.0        11.0        48.0    81/04/20     82/06/23
 00095 CNDUCTVY    AT 25C  MICROMHO      10    10        61.4        9.5        41.0        74.0    81/05/19     82/06/23
 00300        DO               MG/L      14    14         8.9        0.7         8.0        10.5    81/04/20     82/06/23
 00320       BOD ULT FRST      MG/L       9     9         2.9        0.4         2.2         3.5    81/05/19     82/06/23
 00335       COD LOWLEVEL      MG/L      11    11        10.1        1.6         7.7        13.3    81/04/20     82/06/23
 00400        PH                 SU       9     9        7.00       0.22        6.60        7.30    81/04/20     82/04/19
 00410     T ALK     CACO3     MG/L      10    10        19.1        3.6         9.6        21.9    81/04/20     82/04/19
 00500   RESIDUE     TOTAL     MG/L      15    15        68.2       17.7        49.0       105.0    81/04/20     82/06/23
 00530   RESIDUE TOT NFLT      MG/L      15    15        20.2       13.6         5.0        59.0    81/04/20     82/06/23
 00545   RESIDUE SETTLBLE      ML/L       8     2         0.0        0.0         0.0         0.1    81/06/22     82/04/19
 00610 NH3+NH4-  N TOTAL       MG/L      10     0       0.000      0.000       0.010       0.100    81/04/20     82/04/19
 00630  NO2&NO3  N-TOTAL       MG/L      15    15        0.03       0.03        0.01        0.08    81/04/20     82/06/23
 00665 PHOS-TOT              MG/L P      11    11       0.053      0.019       0.030       0.091    81/04/20     82/06/23
 00900 TOT HARD    CACO3       MG/L      11    11        18.6        3.5         8.7        21.8    81/04/20     82/06/23
 00940 CHLORIDE       CL       MG/L      10    10         5.2        1.1         3.3         6.6    81/04/20     82/04/19
 00945  SULFATE  SO4-TOT       MG/L       2     2         1.0        0.0         1.0         1.0    81/04/20     81/05/19
 01002  ARSENIC   AS,TOT       UG/L      10     0         0.0        0.0        10.0        10.0    81/04/20     82/04/19
 01045     IRON   FE,TOT       UG/L      10    10       589.0      377.3       270.0      1370.0    81/04/20     82/04/19
 01051     LEAD   PB,TOT       UG/L      10     6         0.5        0.5         0.0         5.0    81/04/20     82/04/19
 31501 TOT COLI MFIMENDO   /100ML LG     11     7       197.1        5.5         8.0      1800.0    81/04/20     82/06/23
 31616 FEC COLI MFM-FCBR   /100ML LG     10     5        79.2        7.5         5.0       600.0    81/05/19     82/06/23
 32211 CHLRPHYL  A UG/L CORRECTD          9     8        0.84       0.57        0.04        2.11    81/04/20     81/09/14
 70507   PHOS-T    ORTHO   MG/L P        13    13       0.012      0.007       0.003       0.026    81/05/19     82/04/19
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STATION HEADING                                                        POP STORET -- 02-NOV-82
                                                                       ENVIRONMENTAL SERVICES DIVISION
 314LCUG009       FR-PB                                                EPA REGION 10 -- SEATTLE
FERN RIDGE RESERVOIR IN "PERKINS BAY"                                  SUMMARY OF LANE DATA
44 03 24.0 123 18 11.0  2           ALT=     0FT
41039 OREGON       PACIFIC NORTHWEST
WILLAMETTE RIVER                             1309
21ORMISC  REACH=                DRG AREA=      0 SQ MI
RESERV/AMBNT

                              10        62        76        77        95       300       320       335       400       410
 DATE                      WATER     WATER      TURB    TRANSP  CNDUCTVY        DO       BOD       COD        PH     T ALK
 FROM    TIME DEPTH         TEMP  SURF ELE  TRBIDMTR    SECCHI    AT 25C            ULT FRST  LOWLEVEL               CACO3
  TO          FEET          CENT   IN FEET  HACH FTU    INCHES  MICROMHO      MG/L      MG/L      MG/L        SU      MG/L
-------- ---- -----     --------  --------  --------  --------  --------  --------  --------  --------  --------  --------
81/04/20 1200  002          16.0     373.4       8.4        40                 9.1                 9.5      6.80        17
81/05/19 1210  002          16.5     373.6      10.0        34        53       9.2       3.0       7.7                  17
81/06/08 1200  002          18.0     373.6      11.0        30                 8.6
81/06/22 1210  002          20.0     373.5       7.0        34        64       9.2       2.8       9.0      7.10        19
81/07/06 1400  002          20.0     373.4       4.8        48                 8.6
81/07/20 1300  002          22.5     373.1      11.0        20        74       8.4       2.8      10.1      7.00        22
81/08/05 1230  002          22.5     372.7      12.0                           8.0
81/08/24 1430  002          23.5     372.2      12.0        19        71       8.2       2.2       9.2      7.30        22
81/09/14 1230  002          22.0     371.7      13.0        15                 8.4
81/09/28 1140  002          17.0     371.6      14.0        18        70       8.8       2.5      10.1      7.20        21
81/09/28 1145  002          17.0     371.6      13.0        18        68       8.8       2.6      10.4      7.20        21
82/04/05 1240  001           9.0     373.0      13.0                  41                          13.3      6.60        10
82/04/19 1135  002          10.5     373.1      36.0        11        59      10.5       3.5      11.4      7.00        21
82/04/19 1140  006          10.5     373.1      36.0                  58      10.3       3.1      12.6      6.80        21
82/06/23 1300  002          25.0     373.3       5.8        34        56       9.1       3.3       8.3

                             500       530       545       610       630       665       900       940       945      1002
 DATE                    RESIDUE   RESIDUE   RESIDUE  NH3+NH4-   NO2&NO3  PHOS-TOT  TOT HARD  CHLORIDE   SULFATE   ARSENIC
 FROM    TIME DEPTH        TOTAL  TOT NFLT  SETTLBLE   N TOTAL   N-TOTAL               CACO3        CL   SO4-TOT    AS,TOT
  TO          FEET          MG/L      MG/L      ML/L      MG/L      MG/L    MG/L P      MG/L      MG/L      MG/L      UG/L
-------- ---- -----     --------  --------  --------  --------  --------  --------  --------  --------  --------  --------
81/04/20 1200  002            84        23              0.100K      0.01     0.042        17         5         1       10K
81/05/19 1210  002            88        59              0.100K      0.03     0.060        18         5         1       10K
81/06/08 1200  002            63        17                          0.02
81/06/22 1210  002            55         7        0K    0.010K      0.01     0.030        19         6                 10K
81/07/06 1400  002            51         9                          0.01
81/07/20 1300  002            59        19        0K    0.010K      0.01     0.038        22         7                 10K
81/08/05 1230  002            62        17                          0.01
81/08/24 1430  002            66        15        0K    0.010K      0.01     0.048        21         6                 10K
81/09/14 1230  002            58        18                          0.01                                               10K
81/09/28 1140  002            64        18        0K    0.010K      0.01     0.047        21         6                 10K
81/09/28 1145  002            66        18        0K    0.010K      0.01     0.044        21         6                 10K
82/04/05 1240  001            52         5        0K    0.010K      0.08     0.054         9         5
82/04/19 1135  002           101        32         0    0.010K      0.07     0.090        20         3                 10K
82/04/19 1140  006           105        40         0    0.010K      0.07     0.091        20         3                 10K
82/06/23 1300  002            49        11                          0.07     0.036        17

                            1045      1051     31501     31616     32211     70507
 DATE                       IRON      LEAD  TOT COLI  FEC COLI  CHLRPHYL    PHOS-T
 FROM    TIME DEPTH       FE,TOT    PB,TOT  MFIMENDO  MFM-FCBR    A UG/L     ORTHO
  TO          FEET          UG/L      UG/L    /100ML    /100ML  CORRECTD    MG/L P
-------- ---- -----     --------  --------  --------  --------  --------  --------
MORE DATES NEXT PAGE
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STATION=1210RMISC 314LCOG009      FERN RIDGE RESERVOIR IN "PERKINS BAY"           PDP STORET -- 02-NOV-82            PAGE  15
----------------------------------------------------------------------------------  SUMMARY OF LANE DATA


                             1045       1051      31501      31616      32211       70507
  DATE                       IRON       LEAD   TOT COLI   FEC COLI   CHLRPHYL      PHOS-T
  FROM    TIME DEPTH      FE,TOT     PB,TOT   MFIMENDO   MFM-FCBR    A UG/L       ORTHO
   TO            FEET       UG/L       UG/L     /100ML     /100ML   CORRECTD      MG/L P
-------- ---- -----     --------   --------   --------   --------   --------    --------
81/04/20 1200  002           420         5K        310                  0,45
81/05/19 1210  002           500         5K        108        10K       0,45       0,010
81/06/08 1200  002                                                      0,04K      0,020
81/06/22 1210  002           370         5K        20K        10K       1,40       0,010
81/07/06 1400  002                                                      0,63       0,010
81/07/20 1300  002           270         5K        20K         5K       0,40       0,007
81/08/05 1230  002                                                      0,56       0,003
81/08/24 1430  002           390          1         60          5       0,70       0,008
81/09/14 1230  002           420          0                             2,11       0,004
81/09/28 1140  002           420          0        20K         5K                  0,026
81/09/28 1145  002           430          1        20K         10                  0,023
82/04/05 1240  001                                 400        200                  0,004
82/04/19 1135  002          1300          0       1000        520                  0,017
82/04/19 1140  006          1370          1       1800        600                  0,016
82/06/23 1300  002                                   8        20K
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 STATION HEADING                                                                    PDP STORET -- 02-NOV-82               PAGE    8
                                                                                    ENVIRONMENTAL SERVICES DIVISION
  314LCOG008       FR-LB                                                            EPA REGION 10 -- SEATTLE
 FERN RIDGE RESERVOIR IN "LONG TOM BAY"                                             INVENTORY OF LANE DATA
 44 03 55.0 123 19 28.0  2          ALT=    0FT
 41039 OREGON       PACIFIC NORTHWEST
 WILLAMETTE RIVER                           1309
 21ORNISC  REACH=             DRG AREA=      0 SQ MI
 RESERV/AMBNT

SUMMARY OF ALL PARAMETERS FROM   / /   TO 99/99/99
                                          #OBS  #OBS                                                             BEGIN       END
  PARM PARAMETER NAME      UNITS          TOTL  USED        MEAN      STD DEV     MINIMUM     MAXIMUM     PERIOD      PERIOD
 ------ ---------------- --------         ----  ----   ---------   ---------   ---------   ---------   --------    --------
 00010    WATER     TEMP     CENT          17    17        17.4         5.5         8.0        25.0   81/03/23    82/06/23
 00062    WATER SURF ELE  IN FEET          17    17       372.8         0.8       370.5       373.6   81/03/23    82/06/23
 00076     TURB THRIDMTR HACH FTU          17    17         7.6         2.7         3.2        14.0   81/03/23    82/06/23
 00077   TRANSP   SECCHI   INCHES          15    15        36.9        10.5        24.0        53.0   81/03/23    82/06/23
 00095 CNDUCTVY   AT 25C MICROMHO          12    12        54.1        15.1        34.0        72.0   81/03/23    82/06/23
 00300        DO             MG/L          16    16         9.2         0.9         8.2        10.9   81/04/20    82/06/23
 00320       BOD ULT FRST    MG/L           9     9         2.9         0.8         1.8         4.1   81/05/19    82/06/23
 00335       COD LOWLEVEL    MG/L          13    13         8.5         1.5         6.1        10.8   81/03/23    82/06/23
 00400        PH               SU          11    11        6.96        0.23        6.60        7.30   81/03/23    82/04/19
 00410     T ALK    CACO3    MG/L          12    12        16.5         4.4        10.4        21.8   81/03/23    82/04/19
 00500   RESIDUE    TOTAL    MG/L          16    16        53.4        10.0        40.0        74.0   81/04/20    82/06/23
 00530   RESIDUE TOT NFLT    MG/L          16    16        10.7        10.9         2.0        46.0   81/04/20    82/06/23
 00545   RESIDUE SETTLBLE    ML/L           9     0         0.0         0.0         0.0         0.1   81/06/22    82/04/19
 00610 NH3+NH4-  N TOTAL     MG/L          12     0       0.000       0.000       0.010       0.100   81/03/23    82/04/19
 00630   NO2&NO3  N-TOTAL    MG/L          17    15        0.06        0.07        0.01        0.20   81/03/23    82/06/23
 00665 PHOS-TOT            MG/L P          13    13       0.039       0.007       0.024       0.051   81/03/23    82/06/23
 00900 TOT HARD    CACO3     MG/L          13    13        15.7         4.6         9.3        21.7   81/03/23    82/06/23
 00940 CHLORIDE       CL     MG/L          12    12         4.5         1.3         2.6         6.1   81/03/23    82/04/19
 00945   SULFATE  SO4-TOT    MG/L           3     2         1.0         0.0         1.0         1.0   81/03/23    81/05/19
 01002   ARSENIC   AS,TOT    UG/L          13     0         0.0         0.0        10.0        10.0   81/03/23    82/04/19
 01045      IRON   FE,TOT    UG/L          13    13       367.7       108.5       150.0       620.0   81/03/23    82/04/19
 01051      LEAD   PB,TOT    UG/L          13     8         0.4         0.7         0.0         5.0   81/03/23    82/04/19
 31501 TOT COLI MFIMENDO   /100ML LG       13    10        61.5         2.9        12.0       400.0   81/03/23    82/06/23
 31616 FEC COLI MFM-FCBR   /100ML LG       12     4        44.7         2.6         5.0       100.0   81/03/23    82/06/23
 32211 CHLRPHYL   A UG/L CORRECTD           9     8        0.82        0.67        0.04        2.35   81/04/20    81/09/14
 39730     2,4-D WHL SMPL    UG/L           2     0       0.000       0.000       0.100       0.100   81/04/20    81/07/20
 70507    PHOS-T    ORTHO  MG/L P          14    14       0.008       0.006       0.001       0.022   81/05/19    82/04/19
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STATION HEADING

PDP STORET -- 02-NOV-82 PAGE 12
ENVIRONMENTAL SERVICES DIVISION
EPA REGION 10 -- SEATTLE
SUMMARY OF LANE DATA

314LCUG008 FR-LB
FERN RIDGE RESERVOIR IN "LONG TOM BAY"
44 04 56.0 123 19 28.0 2 ALT= 0FT
41039 OREGON PACIFIC NORTHWEST
WILLAMETTE RIVER 1309
21ORMISC REACH= DRG AREA= 0 SO MI
RESERV/AMBNT

DATE FROM TO	TIME	DEPTH FEET	10 WATER TEMP CENT	62 WATER SURF FLE IN FEET	76 TURB TRBIDMTR HACH FTU	77 TRANSP SECCHI INCHES	95 CNDUCTVY AT 25C MICROMHO	300 DO MG/L	320 BOD ULT FRST MG/L	335 COD LOWLEVEL MG/L	400 PH SU	410 T ALK CACO3 MG/L
81/03/23	1445	002	13.0	370.5	14.0	24	54			10.5	6.80	15
81/04/20	1330	002	16.0	373.4	6.0	53		8.7		10.8	7.00	16
81/05/19	1345	002	16.0	373.6	8.0	48	52	9.3	4.1	6.8		17
81/06/08	1330	002	18.0	373.6	8.4	36		8.8				
81/06/22	1420	002	19.0	373.5	7.2	35	64	9.1	2.9	10.8	7.10	19
81/07/06	1440	002	20.5	373.4	4.0	50		8.4				
81/07/20	1330	002	22.5	373.1	3.2	49	69	9.2	3.4	8.2	7.10	21
81/08/05	1330	002	22.0	372.7	4.6	42		8.3				
81/08/24	1530	002	23.5	372.2	7.8	25	72	8.2	1.8	9.2	7.30	22
81/08/24	1550	002	23.5	372.2	8.0	25	72	8.3	2.2	8.8	7.30	22
81/09/14	1325	002	22.0	371.7	7.0	32		9.0				
81/09/28	1210	002	17.0	371.6	10.0	30	72	8.6	2.6	9.8	7.10	22
82/04/05	1410	002	8.5	373.0	8.2	26	35	10.7		8.0	6.70	10
82/04/05	1420	005	8.0	373.0	8.6		34	10.9		7.8	6.90	11
82/04/19	1320	002	10.5	373.1	10.0	27	36	10.4	2.5	6.5	6.70	12
82/04/19	1325	008	10.0	373.1	10.0		35	10.6	2.5	6.1	6.60	12
82/06/23	1340	002	25.0	373.3	3.6	51	54	9.2	4.1	7.8		

DATE FROM TO	TIME	DEPTH FEET	500 RESIDUE TOTAL MG/L	530 RESIDUE TOT NFLT MG/L	545 RESIDUE SETTLBLE ML/L	610 NH3+NH4- N TOTAL MG/L	630 NO2&NO3 N-TOTAL MG/L	665 PHOS-TOT MG/L P	900 TOT HARD CACO3 MG/L	940 CHLORIDE CL MG/L	945 SULFATE SO4-TOT MG/L	1002 ARSENIC AS,TOT UG/L
81/03/23	1445	002				0.100K	0.08	0.051	15	5	1K	10K
81/04/20	1330	002	74	29		0.100K	0.04	0.031	16	4	1	10K
81/05/19	1345	002	72	46		0.100K	0.02	0.050	17	5	1	10K
81/06/08	1330	002	60	9			0.01					
81/06/22	1420	002	53	6	0K	0.010K	0.01K	0.040	19	5		10K
81/07/06	1440	002	52	5			0.01					
81/07/20	1330	002	46	2	0K	0.010K	0.01	0.024	20	6		10K
81/08/05	1330	002	49	6			0.01					
81/08/24	1530	002	60	10	0K	0.010K	0.01K	0.042	22	6		10K
81/08/24	1550	002	59	9	0K	0.010K	0.01	0.046	22	6		10K
81/09/14	1325	002	52	10			0.01					10K
81/09/28	1210	002	62	10	0K	0.010K	0.01	0.043	21	6		10K
82/04/05	1410	002	40	3	0K	0.010K	0.20	0.034	9	3		10K
82/04/05	1420	005	45	5	0K	0.010K	0.20	0.034	9	3		10K
82/04/19	1320	002	44	9	0K	0.010K	0.14	0.037	10	3		10K
82/04/19	1325	008	44	8	0K	0.010K	0.14	0.034	10	3		10K
82/06/23	1340	002	42	4			0.03	0.037	15			
			1045	1051	31501	31616	32211	39730	70507			

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STATION:210RMISC 314LCOGOOR      FERN RIDGE RESERVOIR IN "LONG TOM BAY"      PDP STORET -- 07-NOV-82          PAGE  13
---------------------------------------------------------------------------  SUMMARY OF LANE DATA

                                1045       1051      31501      31616      32211      39730      70507
  DATE                          IRON       LEAD   TOT COLI   FEC COLI   CHLRPHYL      2,4-D     PHOS-T
  FROM    TIME DEPTH          FE,TOT     PB,TOT   MFIMENDO   MFM-FCBR     A UG/L   WHL SMPL      ORTHO
   IO           FEET            UG/L       UG/L     /100ML     /100ML   CORRECTD       UG/L     MG/L P
-------- ---- -----        ---------  ---------  ---------  ---------  ---------  ---------  ---------
81/03/23 1445  002               620         5K         60        10K
81/04/20 1330  002               370         5K         78                  0.23     0.100K
81/05/19 1345  002               480         5K         30        10K       0.34                 0.010
81/06/08 1330  002                                                         0.04K                 0.020
81/06/22 1420  002               350         5K        120         10       1.31                 0.010
81/07/06 1440  002                                                          0.90                 0.010
81/07/20 1330  002               150         5K        20K         5K       0.23     0.100K      0.005
81/08/05 1330  002                                                          0.68                 0.001
81/08/21 1530  002               270          1         20         5K       0.53                 0.006
81/08/24 1550  002               270          0         40         5K                            0.007
81/09/14 1325  002               430          0                             2.35                 0.001
81/09/28 1210  002               340          0         40         5K                            0.022
82/04/05 1410  002               330          0        400        100                            0.007
82/04/05 1420  005               350          2        300        100                            0.007
82/04/19 1320  002               410          0       100K         40                            0.005
82/04/19 1325  008               410          0       100K        20K                            0.006
82/06/23 1340  002                                      12        20K
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  STATION HEADING                                                            PDP STORET -- 02-NOV-82                  PAGE   10
                                                                             ENVIRONMENTAL SERVICES DIVISION
   314LCOG010       FR-PO                                                    EPA REGION 10 -- SEATTLE
  FERN RIDGE RESERVOIR MID POOL                                              INVENTORY OF LANE DATA
  44 06 35.0 123 17 40.0  2          ALT=     0FT
  41039 OREGON        PACIFIC NORTHWEST
  WILLAMETTE RIVER                           1309
  21ORVISC  REACH=              DRG AREA=      0 SQ MI
  RESERV/AMBNT

SUMMARY OF ALL PARAMETERS FROM   /  /   TO 99/99/99
                                        #OBS  #OBS                                                      BEGIN       END
  PAR# PARAMETER NAME       UNITS       TOTL  USED       MEAN      STD DEV     MINIMUM     MAXIMUM    PERIOD      PERIOD
------ ------------------ ---------     ----  ----   ---------   ---------   ---------   ---------   --------   --------
 00010    WATER     TEMP      CENT        39    39        15.3         5.4         6.5        24.0   81/03/23   82/06/23
 00062    WATER SURF ELE   IN FEET        39    39       369.7         5.3       355.0       373.6   81/03/23   82/06/23
 00076    TURB TRBIDMTH   HACH FTU        37    37        18.9        18.6         2.9        75.0   81/03/23   82/06/23
 00077   TRANSP   SECCHI    INCHES        20    20        30.6        19.6         4.0        79.0   81/03/23   82/06/23
 00095 CNDUCTVY   AT 25C  MICROMHO        28    28        55.4        11.3        38.0        73.0   81/03/23   82/06/23
 00300         DO             MG/L        34    34         9.2         1.9         2.8        11.5   81/04/20   82/06/23
 00320       BOD ULT FRST     MG/L        26    26         3.2         1.1         1.4         6.1   81/05/19   82/06/23
 00335       COD LOWLEVEL     MG/L        29    29        10.1         3.5         5.8        21.5   81/03/23   82/06/23
 00400         PH               SU        23    23        6.99        0.28        6.50        7.80   81/03/23   82/04/19
 00410      T ALK    CACO3    MG/L        26    26        16.8         3.2        11.3        22.2   81/03/23   82/04/19
 00500   RESIDUE     TOTAL    MG/L        36    36        76.0        34.9        43.0       178.0   81/04/20   82/06/23
 00530   RESIDUE TOT NFLT     MG/L        35    35        23.3        23.6         2.0        98.0   81/04/20   82/06/23
 00545   RESIDUE SETTLBLE     ML/L        22     0         0.0         0.0         0.0         0.1   81/06/22   82/04/19
 00610 NH3+NH4-  N TOTAL      MG/L        26     0       0.000       0.000       0.010       0.100   81/03/23   82/04/19
 00630  NO2&NO3  N-TOTAL      MG/L        37    35        0.07        0.07        0.01        0.22   81/03/23   82/06/23
 00665 PHOS-TOT             MG/L P        29    29       0.061       0.038       0.011       0.168   81/03/23   82/06/23
 00900 TOT HARD    CACO3      MG/L        29    29        17.2         3.3        11.4        22.7   81/03/23   82/06/23
 00940 CHLORIDE       CL      MG/L        26    26         4.7         1.1         2.9         6.5   81/03/23   82/04/19
 00945  SULFATE  SO4-TOT      MG/L         4     2         1.0         0.0         1.0         1.0   81/03/23   81/05/19
 01002  ARSENIC   AS,TOT      UG/L        26     0         0.0         0.0        10.0        10.0   81/03/23   82/04/19
 01045     IRON   FE,TOT      UG/L        26    26       774.6       699.7        90.0      2850.0   81/03/23   82/04/19
 01051     LEAD   PB,TOT      UG/L        26    20         3.7         9.3         0.0        44.0   81/03/23   82/04/19
 31501 TOT COLI MFIMENDO  /100ML LG       28    22       153.9         8.0         8.0      4100.0   81/03/23   82/06/23
 31616 FEC COLI MFM-FCBR  /100ML LG       27    13       255.9         6.6         5.0      2640.0   81/03/23   82/06/23
 32211 CHLRPHYL   A UG/L CORRECTD         16    16        0.95        1.09        0.11        4.79   81/04/20   81/09/14
 39730    2,4-D WHL SMPL      UG/L         1     0       0.000       0.000       0.100       0.100   81/08/24   81/08/24
 70507   PHOS-T    ORTHO    MG/L P        32    32       0.014       0.011       0.002       0.046   81/05/19   82/04/19
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    STATION HEADING                                                    PDP STORET -- 02-NOV-82
                                                                       ENVIRONMENTAL SERVICES DIVISION
     314LCUG010      FR-PO                                             EPA REGION 10 -- SEATTLE
    FERN RIDGE RESERVOIR MID POOL                                      SUMMARY OF LANE DATA
    44 06 38.0 123 17 40.0  2          ALT=     0FT
    41039 OREGON     PACIFIC NORTHWEST
    WILLAMETTE RIVER                            1309
    210MISC  REACH=              DRG AREA=       0 SQ MI
    RESERV/AMBNT

                                 10        62        76        77        95       300       320       335       400       410
 DATE                         WATER     WATER      TURB    TRANSP  CNDUCTVY        DO       BOD       COD        PH     T ALK
 FROM     TIME DEPTH           TEMP  SURF ELE  TRBIDMTR    SECCHI    AT 25C            ULT FRST  LOWLEVEL               CACO3
  TO            FEET           CENT   IN FEET  HACH FTU    INCHES  MICROMHO      MG/L      MG/L      MG/L        SU      MG/L
-------- ---- -----        -------- --------- --------- --------- --------- --------- --------- --------- --------- ---------
81/03/23 1520  002             13.0     370.5      17.0        22        59                          11.6      6.90        15
81/03/23 1530  020             12.5     370.5
81/04/20 1400  002             15.0     373.4       7.0        49                 9.7                11.9                  17
81/04/20 1410  024             13.0     373.4
81/05/19 1530  002             16.0     373.6       9.0        37        53       9.8       3.6       8.0                  18
81/05/19 1545  020             15.0     373.6       9.5                  54       9.2       2.1       7.0                  18
81/06/08 1500  002             18.0     373.6       8.0        36                 8.6
81/06/08 1530  020             18.0     373.6       8.6
81/06/22 1540  002             20.0     373.5       6.5        36        65      10.0       4.3       9.6      7.20        19
81/06/22 1610  020             19.0     373.5       6.5                  66       9.2       3.1       9.0      7.10        19
81/07/06 1500  002             21.5     373.4       4.3        48                 8.8
81/07/06 1545  020             21.0     373.4       3.7                           8.4
81/07/20 1400  002             22.0     373.1       2.9        65        70       8.8       2.2       7.8      7.00        21
81/07/20 1430  020             20.0     373.1       8.3                  72       5.0       1.9       8.7      7.00        22
81/08/05 1430  002             22.0     372.7       4.0        44                 8.2
81/08/05 1500  020             21.0     372.7      13.0                           6.0
81/08/24 1630  002             23.0     372.2       7.1        24        71       8.4       2.2       8.0      7.40        22
81/08/24 1700  017             22.5     372.2       6.6                  72       7.8       1.4       8.0      7.20        22
81/09/14 1425  002             22.0     371.7       6.0        36                 8.8
81/09/14 1430  019             20.0     371.7      17.0                           6.9
81/10/19 1530  002             14.5     367.5       7.7        38        70      10.4       5.9      10.9      7.80        21
81/10/19 1540  015             14.0     367.5      13.0                  73       7.2       2.3       8.7      7.40        21
81/11/23 1230  002             10.5     355.0      64.0         5        66       9.1       6.1      21.5      7.00        17
81/11/23 1240  002             10.5     355.0      64.0         4        63       9.1       3.1      21.3      6.80        17
81/12/28 1130  002              7.0     361.4      32.0        10        40      10.5       2.5      10.5      6.50        13
81/12/28 1135  010              6.5     361.4      34.0                  52      11.1       3.8      10.0      6.70        16
82/01/25 1310  002              9.0J    361.8      50.0        10        38      10.9       3.3      11.1      6.90        11
82/01/25 1315  002              9.0J    361.8      50.0        10        38      11.1       3.8      10.8      6.90        12
82/01/25 1330  009              9.0J    361.8      75.0                  47      11.2       3.0      13.3      7.10        15
82/02/16 1230  017              8.0     365.8      26.0                  47      11.4       3.7       7.9      7.00        14
82/02/16 1245  002              8.5     365.8      28.0        17        48      11.5       3.4       7.6      7.00        14
82/03/15 1340  020              9.5     369.4      18.0                  43      11.1       3.2       9.0      7.10        14
82/03/15 1345  002             10.0     369.4      19.0        19        42      11.1       3.8       8.0      6.80        14
82/04/19 1400  002             11.0     373.1      12.0        23        46      10.2       3.0       7.5      6.70        15
82/04/19 1405  023             10.0     373.1      20.0                  45      10.3       2.9       9.1      6.60        15
82/04/19 1410  023             10.0     373.1      22.0                  46      10.3       3.6      10.1      6.70        15
82/06/23 1410  002             24.0     373.3       3.1        79        54       8.6       2.2       7.4
82/06/23 1430  020             21.0     373.3       6.4                  55       2.8       3.6       5.8
82/06/23 1440  025             19.5     373.3      10.0L                 56                          12.4
```

STATION:21ORMISC 314LCOG010 FERN RIDGE RESERVOIR MID POOL

PDP STORET -- 02-NOV-82
SUMMARY OF LANE DATA

DATE FROM TO	TIME	DEPTH FEET	500 RESIDUE TOTAL MG/L	530 RESIDUE TOT NFLT MG/L	545 RESIDUE SETTLBLE ML/L	610 NH3+NH4- N TOTAL MG/L	630 NO2&NO3 N-TOTAL MG/L	665 PHOS-TOT MG/L P	900 TOT HARD CACO3 MG/L	940 CHLORIDE CL MG/L	945 SULFATE SO4-TOT MG/L	1002 ARSENIC AS,TOT UG/L
81/03/23	1520	002				0.100K	0.07	0.055	17	5	1K	10K
81/04/20	1400	002	68	25		0.100K	0.02	0.026	17	5	1	10K
81/05/19	1530	002	84	50		0.100K	0.01	0.050	18	5	1K	10K
81/05/19	1545	020	94	43		0.100K	0.02	0.050	18	5	1	10K
81/06/08	1500	002	50	3			0.02					
81/06/08	1530	020	61	5			0.02					
81/06/22	1510	002	49	5	0K	0.010K	0.01	0.030	20	6		10K
81/06/22	1610	020	53	7	0K	0.010K	0.01	0.030	19	6		10K
81/07/06	1500	002	48	9			0.01					
81/07/06	1545	020	54	8			0.01					
81/07/20	1400	002	43	2	0K	0.010K	0.01K	0.020	20	6		10K
81/07/20	1430	020	56	8	0K	0.010K	0.01	0.037	22	6		10K
81/08/05	1430	002	48	4			0.01					
81/08/05	1500	020	67	20			0.01					
81/08/24	1630	002	58	8	0K	0.010K	0.01	0.038	23	6		10K
81/08/24	1700	017	54	8	0K	0.010K	0.01	0.038	22	6		10K
81/09/14	1425	002	48	6			0.01					10K
81/09/14	1430	019	70	28			0.01					10K
81/10/19	1530	002	62	6	0K	0.010K	0.01K	0.036	21	6		10K
81/10/19	1540	015	74	17	0K	0.010K	0.01	0.049	22	7		10K
81/11/23	1230	002	175	63	0K	0.010K	0.21	0.168	21	6		10K
81/11/23	1240	002	178	80	0K	0.010K	0.21	0.149	21	6		
81/12/28	1130	002	82	20	0K	0.010K	0.22	0.071	13	3		10K
81/12/28	1135	010	89	28	0K	0.010K	0.17	0.084	17	4		10K
82/01/25	1310	002	103	34	0K	0.010K	0.20	0.102	12	3		10K
82/01/25	1315	002	101	39	0K	0.010K	0.20	0.100	11	3		10K
82/01/25	1330	009	156	56	0K	0.010K	0.17	0.141	17	4		10K
82/02/16	1230	017	78		0K	0.010K	0.16	0.075	14	4		10K
82/02/16	1245	002	76	16	0K	0.010K	0.16	0.071	15	4		10K
82/03/15	1340	020	56	14	0K	0.010K	0.08	0.052	13	4		10K
82/03/15	1345	002	69	14	0K	0.010K	0.09	0.059	13	4		10K
82/04/19	1400	002	49	9	0K	0.010K	0.04	0.042	14	4		10K
82/04/19	1405	023	73	21	0K	0.010K	0.03	0.060	14	4		
82/04/19	1410	023	78	59	0K	0.010K	0.04	0.065	14	4		10K
82/06/23	1410	002	46	3			0.03	0.025	16			
82/06/23	1430	020	44	5			0.04	0.036	17			
82/06/23	1440	025	143	98			0.06	0.011	19			

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STATION:21ORMISC 3141COG010      FERN RIDGE RESERVOIR MID POOL                                                  PAGE   18
---------------------------------------------------------------------------------  PDP STORET -- 02-NOV-82
                                                                                    SUMMARY OF LANE DATA

                        1045      1051     31501     31616     32211     39730     70507
  DATE                  IRON      LEAD  TOT COLI  FEC COLI  CHLRPHYL     2,4-D    PHOS-T
  FROM  TIME DEPTH    FE,TOT    PB,TOT  MFIMENDO  MFM-FCBR    A UG/L  WHL SMPL     ORTHO
   TO         FEET      UG/L      UG/L    /100ML    /100ML  CORRECTD      UG/L    MG/L P
-------- ---- -----  --------  --------  --------  --------  --------  --------  --------
81/03/23 1520  002       620         5        40       10K
81/04/20 1400  002       400        44        15                0.34
81/05/19 1530  002       420        5K       106        24      0.41               0.010
81/05/19 1545  020       480        5K        13       10K      0.45               0.010
81/06/08 1500  002                                              0.11               0.020
81/06/08 1530  020                                                                 0.020
81/06/22 1540  002       300        5K        40       10K      0.90               0.010
81/06/22 1610  020       340        5K        40       10K      1.02               0.010
81/07/06 1500  002                                              0.79               0.010
81/07/06 1545  020                                              0.54               0.010
81/07/20 1400  002        90        5K       20K        5K      0.45               0.004
81/07/20 1430  020       280        5K       20K        5K      0.23               0.012
81/08/05 1430  002                                              0.68               0.002
81/08/05 1500  020                                              0.63               0.012
81/08/24 1630  002       260         0        40        5K      0.79    0.100K     0.006
81/08/24 1700  017       340         0       20K        5K      0.84               0.006
81/09/14 1425  002       420         1                          4.79               0.003
81/09/14 1430  019       360         1                          2.17               0.010
81/10/19 1530  002       220         0        20        5K                         0.003
81/10/19 1540  015       470         1        29        15                         0.005
81/11/23 1230  002      2850         2      3120      2640                         0.046
81/11/23 1240  002                          4100      2220                         0.036
81/12/28 1130  002      1110         2       540       400                         0.019
81/12/28 1135  010      1350         1      2560       770                         0.023
82/01/25 1310  002      1520         2      1940       940                         0.030
82/01/25 1315  002      1570         2      1720       930                         0.027
82/01/25 1130  009      2580         3      3140      2223                         0.032
82/02/16 1230  017      1510         5       700       200                         0.019
82/02/16 1245  002       650         1       400       200                         0.020
82/03/15 1340  020       550         1      100K       20K                         0.007
82/03/15 1345  002       570         1      100K       20K                         0.006
82/04/19 1400  002       420         1       100        20                         0.006
82/04/19 1405  023                          100K        20                         0.009
82/04/19 1410  023       460         1       100       20K                         0.009
82/06/23 1410  002                             8       20K
82/06/23 1430  020                            15       20K
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STATION HEADING                                                                     PDP STORET -- 02-NOV-82                 PAGE   6
                                                                                    ENVIRONMENTAL SERVICES DIVISION
 3141COG006        FR-DF                                                            EPA REGION 10 -- SEATTLE
FERN RIDGE SHORE SAMPLE- EAST SIDE OF SPILLWAY                                      INVENTORY OF LANE DATA
44 07 11.0 123 17 54.0  2           ALT=    0FT
41039 OREGON        PACIFIC NORTHWEST
WILLAMETTE RIVER                                  1309
210RMISC  REACH=                 DRG AREA=     0 SQ MI
RESERV/AMBNT

SUMMARY OF ALL PARAMETERS FROM   /  /    TO 99/99/99
                                          #OBS  #OBS                                                              BEGIN       END
  PAR# PARAMETER NAME         UNITS       TOTL  USED      MEAN     STD DEV     MINIMUM     MAXIMUM    PERIOD      PERIOD
 ------ ------------------ ---------      ----  ----  ---------   ---------   ---------   ---------   --------    --------
 00010     WATER      TEMP      CENT         3     3        8.3         0.2         8.0         8.5   82/03/02    82/04/05
 00062     WATER SUPF ELE  IN FEET          3     3      369.3         2.6       367.5       373.0   82/03/02    82/04/05
 00076      TURB TRBIDMTR HACH FTU          3     3       19.7         4.7        13.0        23.0   82/03/02    82/04/05
 00095 CNDUCTVY   AT 25C MICROMHO          3     3       48.0         1.6        46.0        50.0   82/03/02    82/04/05
 00300         DO            MG/L          3     3       11.0         0.1        10.9        11.2   82/03/02    82/04/05
 00320        BOD ULT FRST   MG/L          2     2        3.5         0.1         3.4         3.5   82/03/02    82/03/02
 00335        COD LOWLEVEL   MG/L          3     3        8.8         2.4         7.0        12.7   82/03/02    82/04/05
 00400         PH              SU          3     3       6.80        0.14        6.60        6.90   82/03/02    82/04/05
 00410      T ALK    CACO3   MG/L          3     3       15.0         0.3        14.6        15.3   82/03/02    82/04/05
 00500   RESIDUE     TOTAL   MG/L          3     3       67.7         6.9        59.0        76.0   82/03/02    82/04/05
 00530   RESIDUE TOT NFLT    MG/L          3     3       14.0         2.9        10.0        17.0   82/03/02    82/04/05
 00545   RESIDUE SETTLBLE    ML/L          3     0        0.0         0.0         0.0         0.0   82/03/02    82/04/05
 00610 NH3+NH4-   N TOTAL    MG/L          3     0      0.000       0.000       0.010       0.010   82/03/02    82/04/05
 00630   NO2&NO3  N-TOTAL    MG/L          3     3       0.08        0.06        0.01        0.16   82/03/02    82/04/05
 00665 PHOS-TOT             MG/L P         3     3      0.055       0.005       0.048       0.061   82/03/02    82/04/05
 00900 TOT HARD    CACO3     MG/L          3     3       14.9         0.7        13.9        15.6   82/03/02    82/04/05
 00940 CHLORIDE       CL     MG/L          3     3        4.0         0.1         3.9         4.2   82/03/02    82/04/05
 01002  ARSENIC   AS,TOT     UG/L          3     0        0.0         0.0        10.0        10.0   82/03/02    82/04/05
 01045      IRON   FE,TOT    UG/L          3     3      540.0       108.0       390.0       640.0   82/03/02    82/04/05
 01051      LEAD   PB,TOT    UG/L          3     3        1.7         1.2         0.0         3.0   82/03/02    82/04/05
 31501 TOT COLI MFIMENDO   /100ML LG       3     3      462.6         3.0       100.0      1100.0   82/03/02    82/04/05
 31616 FEC COLI MFM-FCBR   /100ML LG       3     2      614.8         1.1        20.0       700.0   82/03/02    82/04/05
 70507    PHOS-T    ORTHO  MG/L P          3     3      0.014       0.010       0.003       0.027   82/03/02    82/04/05
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                                                                                     PDP STORET -- 02-NOV-82                PAGE  10
 STATION HEADING                                                                     ENVIRONMENTAL SERVICES DIVISION
                                                                                     EPA REGION 10 -- SEATTLE
  3141CUG006       FR-DF                                                             SUMMARY OF LANE DATA
 FERN RIDGE SHORE SAMPLE- EAST SIDE OF SPILLWAY
 44 07 11.0 123 17 54.0  2           ALT=     0FT
 41039 OREGON          PACIFIC NORTHWEST
 WILLAMETTE RIVER                              1309
 21ORMISC  REACH=                 DRG AREA=     0 SQ MI
 RESERV/AMBNT

                              10        62        76        95       300       320       335       400       410       500
 DATE                       WATER     WATER      TURB  CNDUCTVY       DO       BOD       COD        PH     T ALK   RESIDUE
 FROM     TIME DEPTH         TEMP  SURF ELE  TRBIDMTR    AT 25C           ULT FRST  LOWLEVEL              CACO3     TOTAL
  TO            FEET         CENT   IN FEET  HACH FTU  MICROMHO      MG/L     MG/L      MG/L        SU      MG/L      MG/L
 -------- ---- -----     --------  --------  --------  --------  --------  --------  --------  --------  --------  --------
 82/03/02 1330  002           8.5     367.5      23.0        50     11.0J     3.5J       7.3      6.90        15        76
 82/03/02 1345  025           8.5     367.5      23.0        48     11.2      3.4        7.0      6.90        15        68
 82/04/05 1530  002           8.0     373.0      13.0        46     10.9                12.2      6.60        15        59

                             530       545       610       630       665       900       940      1002      1045      1051
 DATE                     RESIDUE   RESIDUE  NH3+NH4-   NO2&NO3  PHOS-TOT  TOT HARD  CHLORIDE   ARSENIC      IRON      LEAD
 FROM     TIME DEPTH     TOT NFLT  SETTLBLE   N TOTAL   N-TOTAL               CACO3        CL    AS,TOT    FE,TOT    PB,TOT
  TO            FEET         MG/L      ML/L      MG/L      MG/L    MG/L P      MG/L      MG/L      UG/L      UG/L      UG/L
 -------- ---- -----     --------  --------  --------  --------  --------  --------  --------  --------  --------  --------
 82/03/02 1330  002            15        0K    0.010K      0.08     0.061        16         4       10K       640         2
 82/03/02 1345  025            10        0K    0.010K      0.16     0.056        15         4       10K       590         3
 82/04/05 1530  002            17        0K    0.010K      0.01     0.048        14         4       10K       390         0

                           31501     31616     70507
 DATE                    TOT COLI  FEC COLI    PHOS-T
 FROM     TIME DEPTH     MFIMENDO  MFM-FCBR     ORTHO
  TO            FEET       /100ML    /100ML    MG/L P
 -------- ---- -----     --------  --------  --------
 82/03/02 1330  002          1100       700     0.027
 82/03/02 1345  025           900       540     0.011
 82/04/05 1530  002           100       20K     0.003
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STATION HEADING                                                              PDP STORET -- 02-NOV-82                          PAGE    7
                                                                             ENVIRONMENTAL SERVICES DIVISION
  314LCOG007        FR-DW                                                    EPA REGION 10 -- SEATTLE
 FERN RIDGE SHORE SAMPLE - WEST SIDE OF SPILLWAY                             INVENTORY OF LANE DATA
 44 07 11.0 123 18 02.0  2               ALT=    0FT
 41039 OREGON        PACIFIC NORTHWEST
 WILLAMETTE RIVER                                1309
 21ORWISC  REACH=                    DRG AREA=     0 SQ MI
 STREAM/AMBNT

SUMMARY OF ALL PARAMETERS FROM   /  /   TO 99/99/99
                                              #OBS  #OBS                                                        BEGIN         END
  PAR= PARAMETER NAME             UNITS       TOTL  USED        MEAN       STD DEV       MINIMUM       MAXIMUM    PERIOD       PERIOD
 ------ ------------------------ --------    ----  ----    ---------     ---------     ---------     ---------   --------     --------
  00010     WATER       TEMP        CENT         4     4         9.3           0.6           8.5          10.0   82/03/02     82/04/05
  00062     WATER  SURF ELE   IN FEET            4     4       369.8           2.0         367.5         373.0   82/03/02     82/04/05
  00076      TURB TRBIDMTR  HACH FTU             4     4        19.0           5.3          12.0          27.0   82/03/02     82/04/05
  00077    TRANSP    SECCHI    INCHES            1     1        17.0           0.0          17.0          17.0   82/03/15     82/03/15
  00095 CNDUCTVY    AT 25C  MICROMHO             4     4        44.5           2.2          42.0          48.0   82/03/02     82/04/05
  00300        DO               MG/L             4     4        11.0           0.1          10.9          11.1   82/03/02     82/04/05
  00320       BOD ULT FRST      MG/L             3     3         3.2           0.3           2.8           3.6   82/03/02     82/03/15
  00335       COD LOWLEVEL      MG/L             4     4         9.4           1.2           8.0          10.7   82/03/02     82/04/05
  00400        pH                 SU             4     4        6.83          0.08          6.70          6.90   82/03/02     82/04/05
  00410     T ALK      CACO3    MG/L             4     4        14.2           0.3          13.6          14.5   82/03/02     82/04/05
  00500   RESIDUE      TOTAL    MG/L             4     4        65.3          11.1          51.0          82.0   82/03/02     82/04/05
  00530   RESIDUE TOT NFLT      MG/L             4     4        21.8           7.9          13.0          31.0   82/03/02     82/04/05
  00545   RESIDUE SETTLBLE      ML/L             4     0         0.0           0.0           0.0           0.0   82/03/02     82/04/05
  00610 NH3+NH4-   N TOTAL      MG/L             4     0       0.000         0.000         0.010         0.010   82/03/02     82/04/05
  00630   NO2&NO3  N-TOTAL      MG/L             4     4        0.09          0.06          0.01          0.18   82/03/02     82/04/05
  00665 PHOS-TOT              MG/L P             4     4       0.060         0.014         0.043         0.080   82/03/02     82/04/05
  00900 TOT HARD     CACO3      MG/L             4     4        13.6           0.5          13.0          14.2   82/03/02     82/04/05
  00940 CHLORIDE        CL      MG/L             4     4         3.5           0.0           3.5           3.6   82/03/02     82/04/05
  01002  ARSENIC    AS,TOT      UG/L             4     0         0.0           0.0          10.0          10.0   82/03/02     82/04/05
  01045      IRON    FE,TOT      UG/L            4     4       635.0         200.8         360.0         860.0   82/03/02     82/04/05
  01051      LEAD    PB,TOT      UG/L            4     4         0.7           0.4           0.0           1.0   82/03/02     82/04/05
  31501 TOT COLI MFIMENDO   /100ML LG            4     4       141.4           1.4         100.0         200.0   82/03/02     82/04/05
  31616 FEC COLI MFM-FCBR   /100ML LG            4     3        28.8           1.7          20.0          60.0   82/03/02     82/04/05
  70507    PHOS-T     ORTHO   MG/L P             4     4       0.011         0.008         0.003         0.025   82/03/02     82/04/05
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    STATION HEADING                                                                      PDP STORET -- 02-NOV-82                  PAGE  11
                                                                                         ENVIRONMENTAL SERVICES DIVISION
     3141CUG007        FR-DW                                                             EPA REGION 10 -- SEATTLE
    FERN RIDGE SHORE SAMPLE - WEST SIDE OF SPILLWAY                                      SUMMARY OF LANE DATA
    44 07 11.0 123 18 02.0  2              ALT=     0FT
    41039 OREGON         PACIFIC NORTHWEST
    WILLAMETTE RIVER                                 1309
    21ORMISC  REACH=                   DRG AREA=      0 SQ MI
    STREAM/AMBNT


                                    10         62         76         77         95        300        320        335        400        410
   DATE                          WATER      WATER       TURB     TRANSP   CNDUCTVY         DO        BOD        COD         PH      T ALK
   FROM     TIME DEPTH            TEMP   SURF ELE   TRBIDMTR    SECCHI     AT 25C              ULT FRST   LOWLEVEL                 CACO3
   TO             FEET            CENT    IN FEET   HACH FTU    INCHES   MICROMHO       MG/L       MG/L       MG/L         SU       MG/L
 -------- ---- -----          --------   --------   --------   --------   --------   --------   --------   --------   --------   --------
 82/03/02 1300  002                9.0      367.5       27.0                    42       11.1        2.8        8.0       6.90         14
 82/03/15 1300  020                9.5      369.4       19.0                    44       10.9        3.1       10.7       6.80         14
 82/03/15 1315  002               10.0      369.4       18.0         17         44       11.0        3.6        8.4       6.90         14
 82/04/05 1500  002                8.5      373.0       12.0                    48       11.1                  10.6       6.70         15


                                   500        530        545        610        630        665        900        940       1002       1045
   DATE                        RESIDUE    RESIDUE    RESIDUE   NH3+NH4-   NO2&NO3   PHOS-TOT   TOT HARD   CHLORIDE    ARSENIC       IRON
   FROM     TIME DEPTH           TOTAL   TOT NFLT   SETTLBLE    N TOTAL   N-TOTAL                 CACO3         CL     AS,TOT     FE,TOT
   TO             FEET            MG/L       MG/L       ML/L       MG/L      MG/L     MG/L P       MG/L       MG/L       UG/L       UG/L
 -------- ---- -----          --------   --------   --------   --------   --------   --------   --------   --------   --------   --------
 82/03/02 1300  002                 82         28         0K    0.010K       0.18      0.066         13          4        10K        790
 82/03/15 1300  020                 65         31         0K    0.010K       0.08      0.060         14          4        10K        860
 82/03/15 1315  002                 63         15         0K    0.010K       0.07      0.053         13          4        10K        530
 82/04/05 1500  002                 51         13         0K    0.010K       0.01      0.043         14          4        10K        360


                                  1051      31501      31616      70507
   DATE                           LEAD   TOT COLI   FEC COLI    PHOS-T
   FROM     TIME DEPTH          PB,TOT   MFIMENDO   MFM-FCBR     ORTHO
   TO             FEET            UG/L     /100ML     /100ML     MG/L P
 -------- ---- -----          --------   --------   --------   --------
 82/03/02 1300  002                  1        200         60      0.011
 82/03/15 1300  020                  1        200         20      0.025
 82/03/15 1315  002                  1        100        20K      0.006
 82/04/05 1500  002                  0        100         20      0.003
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   STATION HEADING                                                                 PDP STORET -- 02-NOV-82                       PAGE   1
                                                                                   ENVIRONMENTAL SERVICES DIVISION
   314LCUG001         AH-RO                                                        EPA REGION 10 -- SEATTLE
  AMAZON DIVERSION CHANNEL AT ROYAL AVENUE                                         INVENTORY OF LANE DATA
  44 04 11.0 123 12 11.0  2              ALT=     OFT
  41039 OREGON         PACIFIC NORTHWEST
  WILLAMETTE RIVER
  21UPWISC  REACH=                                1309
  CANAL /AMBNT                         DRG AREA=    0 SQ MI

SUMMARY OF ALL PARAMETERS FROM   / /   TO 99/99/99
                                           #OBS  #OBS                                                            BEGIN       END
  PAR: PARAMETER NAME            UNITS     TOTL  USED       MEAN      STD DEV     MINIMUM     MAXIMUM    PERIOD      PERIOD
 ------ ------------------- ---------    ----  ----  ---------    ---------   ---------   ---------   --------    --------
  00010     WATER      TEMP       CENT      16    16       12.8          4.8         6.5        23.0   81/03/24    82/04/20
  00061    STREAM     FLOW,  INST-CFS      16    16       45.1         59.0         0.0       200.0   81/03/24    82/04/20
  00076      TURB  TRBIDMTR  HACH FTU      16    16       23.3         10.5         8.6        50.0   81/03/24    82/04/20
  00077    TRANSP    SECCHI    INCHES      13    13       16.9          6.9         7.0        32.0   81/03/24    82/04/20
  00095  CNDUCTVY    AT 25C  MICROMHO      15    15      140.1         58.2        65.0       280.0   81/03/24    82/04/05
  00300        DO                MG/L      15    15        8.3          7.3         4.2        11.1   81/03/24    82/04/20
  00320         BOD ULT FRST     MG/L      14    14        4.4          0.9         3.3         6.9   81/04/21    82/04/20
  00335         COD LOWLEVEL     MG/L      16    16       20.5          4.0        11.6        28.3   81/04/21    82/04/20
  00400        PH                  SU      15    15       7.24         0.35        6.60        8.00   81/03/24    82/04/20
  00410     T ALK     CACO3      MG/L      16    16       48.9         24.0        22.8       111.0   81/03/24    82/04/20
  00500   RESIDUE     TOTAL      MG/L      15    15      142.2         38.2        89.0       230.0   81/03/24    82/04/20
  00530   RESIDUE  TOT NFLT      MG/L      15    15       28.9         28.8         2.0       106.0   81/04/21    82/04/20
  00545   RESIDUE  SETTLBLE      ML/L      13     3        0.0          0.0         0.0         0.1   81/04/21    82/04/20
  00610  NH3+NH4-   N TOTAL      MG/L      16     9      0.079        0.014       0.010       0.100   81/06/23    82/04/20
  00630   NO2&NO3   N-TOTAL      MG/L      16    16       0.14         0.11        0.01        0.41   81/03/24    82/04/20
  00665  PHOS-TOT              MG/L P      16    16      0.095        0.030       0.049       0.157   81/03/24    82/04/20
  00900  TOT HARD     CACO3      MG/L      16    16       54.6         23.6        25.2       110.0   81/03/24    82/04/20
  00940  CHLORIDE        CL      MG/L      16    16       10.4          6.3         2.8        21.8   81/03/24    82/04/20
  00945   SULFATE   SO4-TOT      MG/L       3     2        3.5          0.5         1.0         4.0   81/03/24    82/04/20
  01002   ARSENIC    AS,TOT      UG/L      16     0        0.0          0.0        10.0        10.0   81/03/24    81/05/18
  01045      IRON    FE,TOT      UG/L      16    16      903.1        385.5       400.0      1950.0   81/03/24    82/04/20
  01051      LEAD    PB,TOT      UG/L      16    16        7.4          6.0         2.0        26.0   81/03/24    82/04/20
  31501  TOT COLI  MFIMENDO  /100ML LG     15    15     1177.4          3.3        40.0      4000.0   81/03/24    82/04/20
  31615  FEC COLI  MFM-FCBR  /100ML LG     15    15      326.9          3.1        35.0      4000.0   81/03/24    82/04/20
  70507    PHOS-T     ORTHO    MG/L P      14    13      0.039        0.018       0.006       0.066   81/05/18    82/04/20
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STATION HEADING                                                          PDP STORET -- 02-NOV-82                 PAGE    1
                                                                         ENVIRONMENTAL SERVICES DIVISION
 3141CUG001         AM-RO                                                EPA REGION 10 -- SEATTLE
AMAZON DIVERSION CHANNEL AT ROYAL AVENUE                                 SUMMARY OF LANE DATA
44 04 11.0 123 12 11.0  2            ALT=      0FT
41039 OREGON          PACIFIC NORTHWEST
WILLAMETTE RIVER                               1309
21ORMISC  REACH=                 DRG AREA=      0 SQ MI
CANAL /AMBNT

                                10        61        76        77        95       300       320       335       400       410
 DATE                        WATER    STREAM      TURB    TRANSP  CNDUCTVY        DO       BOD       COD        PH     T ALK
 FROM    TIME DEPTH           TEMP     FLOW,  TRBIDMTR    SECCHI    AT 25C            ULT FRST  LOWLEVEL               CACO3
  TO           FEET           CENT  INST-CFS  HACH FTU    INCHES  MICROMHO      MG/L      MG/L      MG/L        SU      MG/L
-------- ---- -----       --------  --------  --------  --------  --------  --------  --------  --------  --------  --------
81/03/24 1425  001            14.0        19      12.0        25       173                          19.3      7.70        55
81/04/21 1030  001            15.0        17      26.0        12                 7.7       3.7      18.7      7.00        72
81/05/18 1230  001            16.0        17      32.0        11       205       7.0      6.9L      22.1                  65
81/06/23 0940  001            23.0         2      18.0        17       162       4.6       4.5      22.1      7.10        59
81/07/21 1330  001            22.0         3      14.0                 216       5.3       4.7      22.7      7.20        84
81/08/25 0945  001            18.0         0      15.0                 280       6.1      6.0L      28.3      8.00       111
81/09/29 0910  001            13.5         0      10.0        24       123       4.2      4.2L      25.5      6.80        23
81/10/19 1330  001            12.5         0       8.6        32       143       8.6       4.4      18.8      7.50        37
81/11/23 0920  001            10.0       150      36.0         7        85       8.4       3.9      26.9      7.00        27
81/12/28 0945  001             6.5       100      26.0        13        72      10.4       3.9      18.0      6.60        25
82/01/25 0945  001             9.0        70      27.0        21       101       9.8       3.5      16.9      7.20        33
82/02/16 0945  001            10.5       200      50.0        10        65       9.7       4.7      22.0      7.40        23
82/03/02 0950  001             8.5        80      31.0        14        83      10.0       4.1      19.2      7.00        30
82/03/15 1000  001             7.5        19      18.0        20       117      11.1       4.3      18.0      7.30        43
82/04/05 1130  001             8.0        35      25.0        14       119      10.5                18.3      7.60        44
82/04/20 1300  001            11.0        10      24.0                 158      10.8       3.3      11.6      7.20        53

                               500       530       545       610       630       665       900       940       945      1002
 DATE                      RESIDUE   RESIDUE   RESIDUE  NH3+NH4-  NO2&NO3  PHOS-TOT  TOT HARD  CHLORIDE   SULFATE   ARSENIC
 FROM    TIME DEPTH          TOTAL  TOT NFLT  SETTLBLE   N TOTAL   N-TOTAL               CACO3        CL   SO4-TOT    AS,TOT
  TO           FEET           MG/L      MG/L      ML/L      MG/L      MG/L    MG/L P      MG/L      MG/L      MG/L      UG/L
-------- ---- -----       --------  --------  --------  --------  --------  --------  --------  --------  --------  --------
81/03/24 1425  001                                        0.100K      0.05     0.067        63        16         3       10K
81/04/21 1030  001             215        74              0.100K      0.14     0.098        83        22         4       10K
81/05/18 1230  001             230       106              0.100K      0.09     0.130        75        20        1K       10K
81/06/23 0940  001             141        25        0K    0.010K      0.02     0.090        63        13                  10K
81/07/21 1330  001             147        26        0K    0.010K      0.01     0.069        87        14                  10K
81/08/25 0945  001             175        27        0K     0.020      0.02     0.063       110        19                  10K
81/09/29 0910  001             106         2        0K     0.020      0.25     0.077        42        13                  10K
81/10/19 1330  001             128        10        0K     0.020      0.03     0.049        51        14                  10K
81/11/23 0920  001             150        30        0K    0.010K      0.41     0.153        32         4                  10K
81/12/28 0945  001              89        13        0K    0.010K      0.18     0.101        27         4                  10K
82/01/25 0945  001             109         4        0K     0.010      0.29     0.093        35         5                  10K
82/02/16 0945  001             150        64        0      0.020      0.16     0.157        25         3                  10K
82/03/02 0950  001             108        13        0      0.040      0.15     0.108        32         4                  10K
82/03/15 1000  001             111         3        0K     0.060      0.13     0.078        44         9                  10K
82/04/05 1130  001             133        12        0      0.040      0.23     0.097        46         7                  10K
82/04/20 1300  001             141        24        0K     0.030      0.15     0.088        59         3                  10K

                              1045      1051     31501     31616     70507
 DATE                         IRON      LEAD  TOT COLI  FEC COLI    PHOS-T
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STATION:21ORMISC 314LCOG001       AMAZON DIVERSION CHANNEL AT ROYAL AVENUE        PDP STORET -- 02-NOV-82
--------------------------------------------------------------------------------  SUMMARY OF LANE DATA


                              1045       1051      31501      31616      70507
  DATE                        IRON       LEAD    TOT COLI   FEC COLI    PHOS-T
  FROM    TIME DEPTH        FE,TOT     PB,TOT    MFIMENDO   MFM-FCBR     ORTHO
   TO           FEET          UG/L       UG/L     /100ML     /100ML    MG/L P
-------- ---- -----      --------   --------   --------   --------   --------
81/03/24 1475  001            780          5       1220        100
81/04/21 1030  001           1180         11
81/05/18 1230  001           1170         17      1000L        590     0.050K
81/06/23 0940  001            700          8        260        210     0.030
81/07/21 1330  001            470          6         40         35     0.022
81/08/25 0945  001            480          3      4000L      4000J     0.006
81/09/29 0910  001            430          3       2560        460     0.054
81/10/19 1330  001            400          2        320        170     0.011
81/11/23 0920  001           1950          6       3500       1400     0.066
81/12/28 0945  001           1130          8       1520       400J     0.047
82/01/25 0945  001            930          4       1260        230     0.044
82/02/16 0945  001           1270         26       4000        540     0.064
82/03/02 0950  001           1000          5       1400        540     0.047
82/03/15 1000  001            720          6       2700        500     0.039
82/04/05 1130  001            880          3       2500        340     0.035
82/04/20 1300  001            960          5       1100         60     0.037
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    STATION HEADING                                                                   PDP STORET -- 02-NOV-82                 PAGE    2
                                                                                      ENVIRONMENTAL SERVICES DIVISION
     314LCOG002        CO-CN                                                          EPA REGION 10 -- SEATTLE
    COYOTE CREEK AT CANTRELL ROAD                                                     INVENTORY OF LANE DATA
    44 02 28.0 123 15 58.0  2          ALT=     0FT
    41039 OREGON        PACIFIC NORTHWEST
    WILLAMETTE RIVER                                  1309
    21ORMISC  REACH=                 DRG AREA=     0 SQ MI
    STREAM/AMBNT

 SUMMARY OF ALL PARAMETERS FROM   /  /    TO 99/99/99
                                            #OBS  #OBS                                                              BEGIN        END
    PAR# PARAMETER NAME         UNITS       TOTL  USED         MEAN      STD DEV      MINIMUM      MAXIMUM       PERIOD       PERIOD
   ------ ----------------- ---------       ----  ----    ---------    ---------    ---------    ---------     --------     --------
   00010    WATER      TEMP      CENT         18    18         12.3          4.9          6.5         27.5     81/03/24     82/04/20
   00061   STREAM     FLOW, INST-CFS          18    18        471.6        472.6          0.0       1600.0     81/03/24     82/04/20
   00076     TURB TRBIDMTR HACH FTU           17    17         78.8         14.6          4.4         60.0     81/03/24     82/04/20
   00077   TRANSP    SECCHI    INCHES         14    14         14.5          4.1          8.0         24.0     81/03/24     82/04/20
   00095 CNDUCTVY    AT 25C MICROMHO          17    17        148.4        209.0         52.0        958.0     81/03/24     82/04/20
   00300       DO               MG/L          16    16          8.4          2.8          0.0         10.4     81/04/21     82/04/20
   00320      BOD ULT FRST      MG/L          11    11          4.5          1.6          2.5          8.3     81/05/18     82/04/20
   00335      COD LOWLEVEL      MG/L          17    17         27.2         58.6          7.1        261.0     81/03/24     82/04/20
   00400       PH                 SU          16    16         7.00         0.18         6.60         7.30     81/03/24     82/04/20
   00410    T ALK     CACO3     MG/L          17    17         30.3         17.6         17.7         97.1     81/03/24     82/04/20
   00500  RESIDUE     TOTAL     MG/L          16    16        147.1        162.6         44.0        768.0     81/04/21     82/04/20
   00530  RESIDUE TOT NFLT      MG/L          16    16         27.9         21.0          1.0         70.0     81/04/21     82/04/20
   00545  RESIDUE SETTLBLE      ML/L          14     4          0.0          0.0          0.0          0.1     81/06/23     82/04/20
   00610 NH3+NH4-  N TOTAL      MG/L          17     9        0.506        1.237        0.010        4.000     81/03/24     82/04/20
   00630  NO2&NO3  N-TOTAL      MG/L          17    17         0.08         0.04         0.01         0.16     81/03/24     82/04/20
   00665 PHUS-TOT             MG/L P          17    17        0.279        0.708        0.043        3.110     81/03/24     82/04/20
   00900 TOT HARD     CACO3     MG/L          17    17         42.4         54.2         17.3        256.0     81/03/24     82/04/20
   00940 CHLORIDE        CL     MG/L          17    17         21.4         49.9          2.8        219.0     81/03/24     82/04/20
   00945  SULFATE  SO4-TOT      MG/L           3     1          0.5          0.0          0.5          1.0     81/03/24     81/05/18
   01002  ARSENIC    AS,TOT     UG/L          17     0          0.0          0.0         10.0         10.0     81/03/24     82/04/20
   01045     IRON    FE,TOT     UG/L          17    17       1210.0        557.2        150.0       2290.0     81/03/24     82/04/20
   01051     LEAD    PB,TOT     UG/L          17    12         10.8         32.9          0.0        120.0     81/03/24     82/04/20
   31501 TOT COLI MFIMENDO  /100ML LG         18    18       2452.7          5.7         20.0     200000.0     81/03/24     82/04/20
   31616 FEC COLI MFM-FCBR  /100ML LG         17    16       2232.2          4.8          5.0     100000.0     81/03/24     82/04/20
   70507   PHOS-T     ORTHO   MG/L P          15    14        0.172        0.490        0.001        1.940     81/05/18     82/04/20
 STATION HEADING                                                                   PDP STORET -- 02-NOV-82               PAGE    3
                                                                                   ENVIRONMENTAL SERVICES DIVISION
  314LCUG002       CO-CN                                                           EPA REGION 10 -- SEATTLE
 COYOTE CREEK AT CANTRELL ROAD                                                     SUMMARY OF LANE DATA
 44 02 28.0 123 15 58.0  2          ALT=     0FT
 41039 OREGON        PACIFIC NORTHWEST
 WILLAMETTE RIVER                            1309
 21OR[illegible]ISC  REACH=            DRG AREA=      0 SQ MI
 STREAM/AMBNT

                                 10        61        76        77        95       300       320       335       400       410
  DATE                        WATER    STREAM      TURB    TRANSP  CNDUCTVY        DO       BOD       COD        PH     T ALK
  FROM     TIME DEPTH          TEMP     FLOW,  TRBIDMTR    SECCHI    AT 25C            ULT FRST  LOWLEVEL               CACO3
   TO               FEET       CENT  INST-CFS  HACH FTU    INCHES  MICROMHO      MG/L      MG/L      MG/L        SU      MG/L
 -------- ---- -----       --------  --------  --------  --------  --------  --------  --------  --------  --------  --------
 81/03/24 1300  001            13.0        85      18.0        16       102                          11.4      7.20        32
 81/04/21 1100  001            13.5        85      18.0        19                 9.9                 7.4      6.80        28
 81/05/18 1500  001            15.0        49      17.0        17       153       8.0       5.1       7.7                  36
 81/06/23 1130  001            21.0        20      16.0        16       168       6.2       4.0      10.1      7.20        40
 81/07/21 1300  001            22.5         3       4.4                  98       8.4       8.3      11.1      7.10        25
 81/08/25 1115  001            21.5         0      12.0                 105                          10.9      7.30        27
 81/09/29 1100  001            14.5        15      32.0         8       958       0.0               261.0      7.10        97
 81/10/06 1545  001            14.0         2                  24       265       3.5
 81/11/23 1000  001            10.0J      900      46.0        10        66       8.6       3.2      23.2      6.90        19
 81/12/28 1000  001             6.5       900      36.0        11        63      10.4       4.8      14.7      6.60        22
 82/01/25 1100  001             9.0      1600      50.0        12        52       9.6       3.1      12.7      7.00        18
 82/02/16 1020  001            10.0      1290      60.0        11        55       8.6       2.5      14.9      7.10        19
 82/03/02 1045  001             8.5       660      46.0        11        63      10.1       5.8      16.0      7.00        24
 82/03/15 1050  001             8.0       255      22.0        17        84      10.4       6.2      14.5      7.00        28
 82/03/15 1100  001             8.0       255      22.0        17        83      10.2       3.8      14.9      7.20        29
 82/04/05 1145  001             7.5       600      32.0                  68      10.4                12.3      6.80        23
 82/04/05 1150  001             7.5       600      33.0                  68      10.4                13.0      6.90        23
 82/04/20 1410  001            10.5       270      26.0        14        72      10.3       3.1       7.1      6.80        24


                                500       530       545       610       630       665       900       940       945      1002
  DATE                      RESIDUE   RESIDUE   RESIDUE  NH3+NH4-   NO2&NO3  PHOS-TOT  TOT HARD  CHLORIDE   SULFATE   ARSENIC
  FROM     TIME DEPTH         TOTAL  TOT NFLT  SETTLBLE   N TOTAL   N-TOTAL               CACO3        CL   SO4-TOT    AS,TOT
   TO               FEET       MG/L      MG/L      ML/L      MG/L      MG/L    MG/L P      MG/L      MG/L      MG/L      UG/L
 -------- ---- -----       --------  --------  --------  --------  --------  --------  --------  --------  --------  --------
 81/03/24 1300  001                                        0.100K      0.07     0.072        35        11        1K       10K
 81/04/21 1100  001             110        34              0.100K      0.07     0.068        32        10         1       10K
 81/05/18 1500  001             160        70              0.150       0.07     0.110        50        24        1K       10K
 81/06/23 1130  001              44        18        0K    0.170       0.11     0.100        53        26                  10K
 81/07/21 1300  001              66         1        0K    0.020       0.01     0.043        31        14                  10K
 81/08/25 1115  001              98        10        0K    0.010K      0.02     0.058        34        14                  10K
 81/09/29 1100  001             768        66        0K    4.000       0.11     3.110       256       219                  10K
 81/11/23 1000  001             148        49        0K    0.010K      0.16     0.143        22         5                  10K
 81/12/28 1000  001             113        40        0K    0.010K      0.10     0.120        22         4                  10K
 82/01/25 1100  001              99        10        0K    0.010K      0.11     0.098        17         3                  10K
 82/02/16 1020  001             126        23        0     0.010K      0.10     0.130        19         4                  10K
 82/03/02 1045  001             132        49        0     0.030       0.09     0.149        24         4                  10K
 82/03/15 1050  001             100         8        0K    0.060       0.06     0.120        29         7                  10K
 82/03/15 1100  001             104        12        0K    0.060       0.06     0.122        29         7                  10K
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STATION:210HMISC 314LCOG002      COYOTE CREEK AT CANTRELL ROAD                                PDP STORET -- 02-NOV-82                    PAGE    4
------------------------------------------------------------------------------------------   SUMMARY OF LANE DATA

                                 500        530        545        610        630        665        900        940        945       1002
  DATE                       RESIDUE    RESIDUE    RESIDUE   NH3+NH4-    NO2&NO3   PHOS-TOT   TOT HARD   CHLORIDE    SULFATE    ARSENIC
  FROM     TIME DEPTH          TOTAL   TOT NFLT  SETTLBLE    N TOTAL    N-TOTAL                 CACO3         CL    SO4-TOT     AS,TOT
   TO             FEET          MG/L       MG/L      ML/L       MG/L       MG/L     MG/L P       MG/L       MG/L       MG/L       UG/L
-------- ---- -----      --------   --------   --------   --------   --------   --------   --------   --------   --------   --------
82/04/20 1410  001                92         35          0    0,010K       0,06      0,075         24          5                   10K

                                1045       1051      31501      31616      70507
  DATE                          IRON       LEAD   TOT COLI   FEC COLI     PHOS-T
  FROM     TIME DEPTH         FE,TOT     PB,TOT   MFIMENDU   MFM-FCBR      ORTHO
   TO             FEET          UG/L       UG/L    /100ML     /100ML     MG/L P
-------- ---- -----      --------   --------   --------   --------   --------
81/03/24 1300  001              1060         5K       3160       2250
81/04/21 1100  001               990         5K       2300
81/05/18 1500  001              1000         5K      1000L      1000L     0,050K
81/06/23 1130  001               830         5K       2540       1860      0,050
81/07/21 1300  001               160         5K         20         5K      0,010
81/08/25 1115  001               500          0         80         30      0,001
81/09/29 1100  001              2290          0    200000J    100000J      1,940
81/10/06 1545  001                                    1400       1240
81/11/23 1000  001              2290        120       1960       1680      0,042
81/12/28 1000  001              1700          1       8600      4800J      0,039
82/01/25 1100  001              1440          1       1960       1113      0,033
82/02/16 1020  001              1370          2       1300       1120      0,044
82/03/02 1045  001              1600          1      10300      6000J      0,054
82/03/15 1050  001               880          1       9100       6240      0,051
82/03/15 1100  001               950          1      12300       5640      0,050
82/04/05 1145  001               900          1       5000       2640      0,036
82/04/05 1150  001               930          0       3600       3960      0,036
82/04/20 1410  001              1730          1       1400       1100      0,028
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                                                                                    PDP STORET -- 02-NOV-82                      PAGE    3
   STATION HEADING                                                                  ENVIRONMENTAL SERVICES DIVISION
                                                                                    EPA REGION 10 -- SEATTLE
   314LCOG003       CU-PT                                                           INVENTORY OF LANE DATA
  COYOTE CREEK AT PETZOLD ROAD
  44 00 19.0 123 10 07.0  2           ALT=    0FT
  41039 OREGON        PACIFIC NORTHWEST
  WILLAMETTE RIVER                               1309
  21ORAISC  REACH=              DRG AREA=      0 SQ MI
  STREAM/AMBNT

 SUMMARY OF ALL PARAMETERS FROM   /  /    TO 99/99/99
                                             #OBS  #OBS                                                                 BEGIN      END
   PAR# PARAMETER NAME           UNITS       TOTL  USED       MEAN       STD DEV     MINIMUM      MAXIMUM      PERIOD      PERIOD
  ------ ----------------- ---------         ----  ----   ---------    ---------   ---------    ---------    --------    --------
  00010     WATER      TEMP     CENT           4     4         11.9          1.7         9.0         13.5     81/09/29    82/01/25
  00061    STREAM     FLOW, INST-CFS           4     4        254.8        430.3         3.0       1000.0     81/09/29    82/01/25
  00076      TURB TRBIDMTR HACH FTU            3     3         31.3         13.6        18.0         50.0     81/09/29    82/01/25
  00077    TRANSP    SECCHI   INCHES           4     4         14.8          5.4        10.0         23.0     81/09/29    82/01/25
  00095 CNDUCTVY    AT 25C MICROMHO            4     4        151.5         70.7        47.0        239.0     81/09/29    82/01/25
  00300        DO               MG/L           3     3          9.0          0.7         8.1          9.8     81/10/06    82/01/25
  00320       BOD ULT FRST      MG/L           3     3          3.9          1.5         2.5          6.0     81/10/06    82/01/25
  00335       COD LOWLEVEL      MG/L           3     3         13.7          3.6         9.7         18.5     81/09/29    82/01/25
  00400        PH                 SU           3     3         7.23         0.25        6.90         7.50     81/09/29    82/01/25
  00410     T ALK     CACO3     MG/L           3     3         25.7          7.3        15.8         33.0     81/09/29    82/01/25
  00500   RESIDUE     TOTAL     MG/L           3     3        133.0         30.0        99.0        172.0     81/09/29    82/01/25
  00530   RESIDUE TOT NFLT      MG/L           3     3         16.3         10.1         6.0         30.0     81/09/29    82/01/25
  00545   RESIDUE SETTLBLE      ML/L           3     0          0.0          0.0         0.0          0.0     81/09/29    82/01/25
  00610 NH3+NH4-   N TOTAL      MG/L           3     1        0.010        0.000       0.010        0.010     81/09/29    82/01/25
  00630  NO2&NO3   N-TOTAL      MG/L           3     3         0.09         0.03        0.05         0.12     81/09/29    82/01/25
  00665 PHOS-TOT              MG/L P           3     3        0.084        0.010       0.069        0.092     81/09/29    82/01/25
  00900 TOT HARD     CACO3      MG/L           3     3         36.2         14.6        15.9         49.5     81/09/29    82/01/25
  00940 CHLORIDE        CL      MG/L           3     3         19.1         13.2         2.6         35.0     81/09/29    82/01/25
  01002  ARSENIC    AS,TOT      UG/L           2     0          0.0          0.0        10.0         10.0     81/10/19    82/01/25
  01045      IRON    FE,TOT     UG/L           2     2       1325.0        175.0      1150.0       1500.0     81/10/19    82/01/25
  01051      LEAD    PB,TOT     UG/L           2     2          0.5          0.5         0.0          1.0     81/10/19    82/01/25
  31501 TOT COLI MFIMENDO   /100ML LG          3     3        506.8          3.7       140.0       3100.0     81/10/06    82/01/25
  31616 FEC COLI MFM-FCBR   /100ML LG          3     3        241.1          4.4        55.0       1820.0     81/10/06    82/01/25
  70507    PHOS-T    ORTHO    MG/L P           3     3        0.042        0.018       0.028        0.068     81/09/29    82/01/25
 STATION HEADING                                                                  PDP STORET -- 02-NOV-82                     PAGE    5
                                                                                  ENVIRONMENTAL SERVICES DIVISION
  3141COG003       CO-PT                                                          EPA REGION 10 -- SEATTLE
 COYOTE CREEK AT PETZOLD ROAD                                                     SUMMARY OF LANE DATA
 44 00 19.0 123 16 07.0  2          ALT=     0FT
 41039 OREGON          PACIFIC NORTHWEST
 WILLAMETTE RIVER                             1309
 21ORWISC  REACH=               DRG AREA=      0 SQ MI
 STREAM/AMBNT


  DATE                          10        61        76        77        95       300       320       335       400       410
  FROM     TIME DEPTH        WATER    STREAM      TURB    TRANSP  CNDUCTVY        DO       BOD       COD        PH     T ALK
   TO             FEET        TEMP     FLOW,  TRBIDMTR    SECCHI    AT 25C            ULT FRST  LOWLEVEL               CACO3
                              CENT  INST-CFS  HACH FTU    INCHES  MICROMHO      MG/L      MG/L      MG/L        SU      MG/L
 -------- ---- -----      --------  --------  --------  --------  --------  --------  --------  --------  --------  --------
 81/09/29 1030  001           13.5        12      26.0        10       185                          18.5      7.30        28
 81/10/06 1510  001           13.0         4                  16       239       8.1       6.0
 81/10/19 1345  001           12.0         3      16.0        23       135       9.2       3.1      12.8      7.50        33
 82/01/25 1030  001            9.0     1000J      50.0        10        47       9.8       2.5       9.7      6.90        16


  DATE                         500       530       545       610       630       665       900       940      1002      1045
  FROM     TIME DEPTH      RESIDUE   RESIDUE   RESIDUE  NH3+NH4-   NO2&NO3  PHOS-TOT  TOT HARD  CHLORIDE   ARSENIC      IRON
   TO             FEET       TOTAL  TOT NFLT  SETTLBLE   N TOTAL   N-TOTAL               CACO3        CL    AS,TOT    FE,TOT
                              MG/L      MG/L      ML/L      MG/L      MG/L    MG/L P      MG/L      MG/L      UG/L      UG/L
 -------- ---- -----      --------  --------  --------  --------  --------  --------  --------  --------  --------  --------
 81/09/29 1030  001            172        30        0K     0.010      0.05     0.090        50        35
 81/10/19 1345  001            128         6        0K    0.010K      0.11     0.069        43        20       10K      1150
 82/01/25 1030  001             99        13        0K    0.010K      0.12     0.092        16         3       10K      1500


  DATE                        1051     31501     31616     70507
  FROM     TIME DEPTH         LEAD  TOT COLI  FEC COLI    PHOS-T
   TO             FEET      PB,TOT  MFIMENDO  MFM-FCBR     ORTHO
                              UG/L    /100ML    /100ML    MG/L P
 -------- ---- -----      --------  --------  --------  --------
 81/09/29 1030  001                                        0.068
 81/10/06 1510  001                     3100      1820
 81/10/19 1345  001              0       140        55     0.028
 82/01/25 1030  001              1       300       140     0.031
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     STATION HEADING                                                                       PDP STORET -- 02-NOV-82                  PAGE   13
                                                                                           ENVIRONMENTAL SERVICES DIVISION
     314LCOG013        SP-CP                                                               EPA REGION 10 -- SEATTLE
    SPENCER CREEK AT CROW ROAD                                                             INVENTORY OF LANE DATA
    44 00 26.0 123 12 11.0  2             ALT=    0FT
    41039 OREGON         PACIFIC NORTHWEST
    WILLAMETTE RIVER                                1309
    210MMISC  REACH=                    DRG AREA=      0 SQ MI
    STREAM/AMBNT

  SUMMARY OF ALL PARAMETERS FROM   /  /   TO 99/99/99
                                              #OBS  #OBS                                                         BEGIN       END
    PAR# PARAMETER NAME            UNITS      TOTL  USED       MEAN      STD DEV     MINIMUM     MAXIMUM    PERIOD      PERIOD
   ------ ------------------ ---------        ----  ----   ---------   ---------   ---------   ---------   --------    --------
    00010     WATER       TEMP      CENT          1     1         9.0         0.0         9.0         9.0   82/01/25    82/01/25
    00061    STREAM    FLOW, INST-CFS          1     1       500.0         0.0       500.0       500.0   82/01/25    82/01/25
    00076      TURB TRBIDMTR HACH FTU          1     1        40.0         0.0        40.0        40.0   82/01/25    82/01/25
    00077    TRANSP    SECCHI   INCHES         1     1        13.0         0.0        13.0        13.0   82/01/25    82/01/25
    00095 CNDUCTVY    AT 25C MICROMHO          1     1        65.0         0.0        65.0        65.0   82/01/25    82/01/25
    00300        DO                MG/L         1     1        10.0         0.0        10.0        10.0   82/01/25    82/01/25
    00320       BOD ULT FRST       MG/L         1     1         3.0         0.0         3.0         3.0   82/01/25    82/01/25
    00335       COD LOWLEVEL       MG/L         1     1        13.8         0.0        13.8        13.8   82/01/25    82/01/25
    00400        PH                  SU         1     1        7.00        0.00        7.00        7.00   82/01/25    82/01/25
    00410     T ALK      CACO3     MG/L         1     1        24.8         0.0        24.8        24.8   82/01/25    82/01/25
    00500   RESIDUE      TOTAL     MG/L         1     1       115.0         0.0       115.0       115.0   82/01/25    82/01/25
    00530   RESIDUE TOT NFLT       MG/L         1     1        18.0         0.0        18.0        18.0   82/01/25    82/01/25
    00545   RESIDUE SETTLBLE       ML/L         1     0         0.0         0.0         0.0         0.0   82/01/25    82/01/25
    00610 NH3+NH4-   N TOTAL       MG/L         1     0       0.000       0.000       0.010       0.010   82/01/25    82/01/25
    00630   NO2&NO3  N-TOTAL       MG/L         1     1        0.08        0.00        0.08        0.08   82/01/25    82/01/25
    00665 PHOS-TOT               MG/L P         1     1       0.090       0.000       0.090       0.090   82/01/25    82/01/25
    00900 TOT HARD     CACO3       MG/L         1     1        24.1         0.0        24.1        24.1   82/01/25    82/01/25
    00940 CHLORIDE        CL       MG/L         1     1         3.4         0.0         3.4         3.4   82/01/25    82/01/25
    01002  ARSENIC    AS,TOT       UG/L         1     0         0.0         0.0        10.0        10.0   82/01/25    82/01/25
    01045      IRON   FE,TOT       UG/L         1     1      1310.0         0.0      1310.0      1310.0   82/01/25    82/01/25
    01051      LEAD   PB,TOT       UG/L         1     1         1.0         0.0         1.0         1.0   82/01/25    82/01/25
    31501 TOT COLI MFIMENDO    /100ML LG        1     1       140.0         1.0       140.0       140.0   82/01/25    82/01/25
    31616 FEC COLI MFM-FCBR    /100ML LG        1     1        70.0         1.0        70.0        70.0   82/01/25    82/01/25
    70507    PHOS-T    ORTHO   MG/L P          1     1       0.076       0.000       0.026       0.026   82/01/25    82/01/25
    STATION HEADING                                                                          POP STORET -- 02-NOV-82                      PAGE   23
                                                                                             ENVIRONMENTAL SERVICES DIVISION
    314LCOG013        SP-CR                                                                  EPA REGION 10 -- SEATTLE
   SPENCER CREEK AT CROW ROAD                                                                SUMMARY OF LANE DATA
   44 00 26.0 123 12 11.0  2            ALT=     0FT
   41039 OREGON         PACIFIC NORTHWEST
   WILLAMETTE RIVER                              1309
   21ORMISC  REACH=                DRG AREA=      0 SQ MI
   STREAM/AMBNT

                                10        61        76        77        95       300       320       335       400       410
 DATE                        WATER    STREAM      TURB    TRANSP  CNDUCTVY        DO       BOD       COD        PH     T ALK
 FROM     TIME DEPTH          TEMP     FLOW,  THRIDMTR    SECCHI    AT 25C                ULT FRST  LOWLEVEL              CACO3
  TO           FEET           CENT  INST-CFS  HACH FTU    INCHES  MICROMHO      MG/L      MG/L      MG/L        SU      MG/L
-------- ---- -----       --------  --------  --------  --------  --------  --------  --------  --------  --------  --------
82/01/25 1010  001             9.0      500J      40.0        13        65      10.0       3.0      13.8      7.00        25

                               500       530       545       610       630       665       900       940      1002      1045
 DATE                      RESIDUE   RESIDUE   RESIDUE  NH3+NH4-   NO2&NO3  PHOS-TOT  TOT HARD  CHLORIDE   ARSENIC      IRON
 FROM     TIME DEPTH         TOTAL  TOT NFLT  SETTLBLE   N TOTAL   N-TOTAL               CACO3        CL    AS,TOT    FE,TOT
  TO           FEET           MG/L      MG/L      ML/L      MG/L      MG/L    MG/L P      MG/L      MG/L      UG/L      UG/L
-------- ---- -----       --------  --------  --------  --------  --------  --------  --------  --------  --------  --------
82/01/25 1010  001             115        18        0K    0.010K      0.08     0.090        24         3       10K      1310

                              1051     31501     31616     70507
 DATE                         LEAD  TOT COLI  FEC COLI    PHOS-T
 FROM     TIME DEPTH        PB,TOT  MFIMENDO  MFM-FCBR     ORTHO
  TO           FEET           UG/L    /100ML    /100ML    MG/L P
-------- ---- -----       --------  --------  --------  --------
82/01/25 1010  001               1       140        70     0.026
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  STATION HEADING                                                             PDP STORET -- 02-NOV-82              PAGE   12
                                                                              ENVIRONMENTAL SERVICES DIVISION
  314LCOGC12        LT-NF                                                     EPA REGION 10 -- SEATTLE
 LONG TOM RIVER AT ELMIRA- ROUTE F BRIDGE                                     INVENTORY OF LANE DATA
 44 03 52.0 123 21 14.0  2             ALT=    0FT
 41039 OREGON        PACIFIC NORTHWEST
 WILLAMETTE RIVER                                 1309
 210RMISC  REACH=                 DRG AREA=     0 SQ MI
 STREAM/AMBNT

SUMMARY OF ALL PARAMETERS FROM   /  /   TO 99/99/99
                                              #OBS  #OBS                                                     BEGIN       END
  PAR# PARAMETER NAME              UNITS      TOTL  USED       MEAN      STD DEV      MINIMUM      MAXIMUM    PERIOD      PERIOD
 ------ ------------------ ---------         ----  ----   ---------    ---------    ---------    ---------   --------    --------
  00010    WATER      TEMP      CENT           19    19        12.3          3.9          6.5         20.0   81/03/24    82/04/20
  00061   STREAM     FLOW, INST-CFS            19    19       430.4        501.1         16.0       1940.0   81/03/24    82/04/20
  00076     TURB TRBIDMTR HACH FTU             19    19         9.2          4.0          4.6         17.0   81/03/24    82/04/20
  00077   TRANSP    SECCHI   INCHES            15    15        29.1          6.8         17.0         44.0   81/03/24    82/04/20
  00095 CNDUCTVY   AT 25C MICROMHO             19    18        45.2         11.1         32.0         66.0   81/03/24    82/04/20
  00300       DO              MG/L             17    17         9.3          1.1          7.2         10.6   81/04/21    82/04/20
  00320      BOD ULT FRST     MG/L             16    16         2.8          1.0          1.8          4.8   81/04/21    82/04/20
  00335      COD LOWLEVEL     MG/L             19    19         8.2          2.5          4.9         16.0   81/03/24    82/04/20
  00400       PH                SU             18    18        6.89         0.26         6.50         7.40   81/03/24    82/04/20
  00410    T ALK     CACO3    MG/L             19    19        13.9          3.5          8.2         20.6   81/03/24    82/04/20
  00500  RESIDUE     TOTAL    MG/L             17    17        62.1          9.9         45.0         85.0   81/04/21    82/04/20
  00530  RESIDUE TOT NFLT     MG/L             17    17        19.2         13.7          4.0         51.0   81/04/21    82/04/20
  00545  RESIDUE SETTLBLE     ML/L             15     5         0.0          0.0          0.0          0.1   81/06/23    82/04/20
  00610 NH3+NH4-   N TOTAL    MG/L             19     3       0.050        0.057        0.010        0.130   81/03/24    82/04/20
  00630  NO2&NO3   N-TOTAL    MG/L             19    19        0.19         0.08         0.09         0.47   81/03/24    82/04/20
  00665 PHOS-TOT            MG/L P             19    19       0.052        0.017        0.031        0.111   81/03/24    82/04/20
  00900 TOT HARD     CACO3    MG/L             19    19        12.4          3.5          7.6         19.7   81/03/24    82/04/20
  00940 CHLORIDE        CL    MG/L             19    19         3.8          0.9          2.6          5.7   81/03/24    82/04/20
  00945  SULFATE   SO4-TOT    MG/L              4     1         0.0          0.0          0.0          1.0   81/03/24    81/05/18
  01002  ARSENIC    AS,TOT    UG/L             19     0         0.0          0.0         10.0         10.0   81/03/24    82/04/20
  01045     IRON    FE,TOT    UG/L             19    19       822.6        241.1        450.0       1270.0   81/03/24    82/04/20
  01051     LEAD    PB,TOT    UG/L             19    12         0.7          0.6          0.0          5.0   81/03/24    82/04/20
  31501 TOT COLI MFIMENDO   /100ML LG          19    19       238.5          2.5         40.0       1080.0   81/03/24    82/04/20
  31616 FEC COLI MFM-FCBR   /100ML LG          19    18        74.0          2.5         11.0        480.0   81/03/24    82/04/20
  39730    2,4-D WHL SMPL     UG/L LG           1     0       0.000        0.000        0.100        0.100   81/06/23    81/06/23
  70507   PHOS-T     ORTHO  MG/L P             16    16       0.019        0.019        0.000        0.089   81/05/18    82/04/20
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   STATION HEADING                                                                         PDP STORET -- 02-NOV-82                PAGE  21
                                                                                           ENVIRONMENTAL SERVICES DIVISION
   314LCUG012        LT-RF                                                                 EPA REGION 10 -- SEATTLE
  LONG TOM RIVER AT ELMIRA- ROUTE F BRIDGE                                                 SUMMARY OF LANE DATA
  44 03 52.0 123 21 11.0  2           ALT=     0FT
  41039 OREGON        PACIFIC NORTHWEST
  WILLAMETTE RIVER                             1309
  21ORHISC  REACH=               DRG AREA=      0 SQ MI
  STREAM/AMBNT


                               10        61        76        77        95       300       320       335       400       410
   DATE                      WATER    STREAM      TURB    TRANSP  CNDUCTVY        DO       BOD       COD        PH     T ALK
   FROM    TIME DEPTH         TEMP     FLOW,  TRBIDMTR   SECCHI    AT 25C            ULT FRST  LOWLEVEL               CACO3
    TO           FEET         CENT  INST-CFS  HACH FTU   INCHES  MICROMHO      MG/L      MG/L      MG/L        SU      MG/L
  -------- ---- -----     --------  --------  --------  --------  --------  --------  --------  --------  --------  --------
  81/03/24 1130  001          12.0       200       5.3        37        44                          8.2      6.60        14
  81/03/24 1135  001          12.0       200       5.5        37        44                          7.4      6.80        13
  81/04/21 1330  001          13.0       200       4.6        44                10.4       2.4       6.7      6.70        13
  81/05/18 1320  001          13.0       132       7.5        30        40       9.5       3.5       7.3                  14
  81/06/23 1100  001          17.0        86       6.4        34        52       8.9       2.2       7.6      7.00        17
  81/07/21 1045  001          20.0        31       7.1        30        56       7.2       4.7       8.0      7.00        18
  81/07/21 1050  001          20.0        30       7.3                  55       7.4       4.8       8.0      7.10        18
  81/08/25 1045  001          19.0        16      14.0                  66       7.4       2.2      10.6      7.20        21
  81/09/23 1130  001          13.0        48      10.0        25        60       8.4       4.2      16.0      7.20        18
  81/10/19 1440  001          12.0        30       5.0                  59      10.0       3.3       7.1      7.30        18
  81/10/19 1445  001          12.0        30       5.2                  59       9.0       2.4       7.6      7.40        17
  81/11/23 1100  001          10.0       910      13.0        20        38       9.1       1.9      12.3      6.70        10
  81/12/28 1045  001           6.5       964      15.0        17        35      10.6       2.7       7.4      6.50        11
  82/01/25 1200  001           9.0      1940      15.0        24        32       9.9       2.1       8.7      6.70         8
  82/02/16 1050  001          10.0      1130      17.0        25        32       9.3       1.8       8.7      7.00        10
  82/03/02 1130  001           8.5       720      12.0        28        33      10.4       2.2       5.2      6.70        11
  82/03/15 1130  001           8.5       360       6.0        38        37      10.6       2.7       6.0      6.90        12
  82/04/05 1350  001           8.0       700      12.0        23        36      10.5                 7.8      6.60        11
  82/04/20 1350  001          11.0       450       6.7        34        35      10.2       2.0       4.9      6.60        12


                              500       530       545       610       630       665       900       940       945      1002
   DATE                    RESIDUE   RESIDUE   RESIDUE  NH3+NH4-   NO2&NO3  PHOS-TOT  TOT HARD  CHLORIDE   SULFATE   ARSENIC
   FROM    TIME DEPTH        TOTAL  TOT NFLT  SETTLBLE   N TOTAL   N-TOTAL               CACO3        CL   SO4-TOT    AS,TOT
    TO           FEET         MG/L      MG/L      ML/L      MG/L      MG/L    MG/L P      MG/L      MG/L      MG/L      UG/L
  -------- ---- -----     --------  --------  --------  --------  --------  --------  --------  --------  --------  --------
  81/03/24 1130  001                                      0.100K      0.13     0.052        11         4        1K       10K
  81/03/24 1135  001                                      0.100K      0.13     0.051        12         4        1K       10K
  81/04/21 1330  001            64        27              0.100K      0.15     0.042        12         3        0        10K
  81/05/18 1320  001            78        51              0.100K      0.12     0.060        13         3        1K       10K
  81/06/23 1100  001            56         6        0K    0.010K      0.11     0.040        15         6                  10K
  81/07/21 1045  001            53         8        0K    0.010       0.23     0.052        16         4                  10K
  81/07/21 1050  001            54        10        0K    0.010       0.23     0.053        16         5                  10K
  81/08/25 1045  001            65        24        0K    0.010K      0.09     0.060        20         5                  10K
  81/09/29 1130  001            59         8        0K    0.130       0.15     0.111        15         5                  10K
  81/10/19 1440  001            67         4        0K    0.010K      0.20     0.035        17         5                  10K
  81/10/19 1445  001            66         4        0K    0.010K      0.20     0.036        17         5                  10K
  81/11/23 1100  001            85        32        0     0.010K      0.47     0.067        11         4                  10K
  81/12/28 1045  001            66        43        0K    0.010K      0.27     0.051         9         3                  10K
  82/01/25 1200  001            58        22        0K    0.010K      0.27     0.051         8         3                  10K
  82/02/16 1050  001            70        32        0     0.010K      0.25     0.067         8         3                  10K
  MORE DATES NEXT PAGE
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STATION:210RMISC 314LCOG012      LONG TOM RIVER AT ELMIRA- ROUTE F BRIDGE        PDP STORET -- 02-NOV-82                   PAGE   22
-------------------------------------------------------------------------------- SUMMARY OF LANE DATA

                                500       530       545       610       630       665       900       940       945      1002
  DATE                      RESIDUE   RESIDUE   RESIDUE  NH3+NH4-  NO2&NO3  PHOS-TOT   TOT HARD  CHLORIDE   SULFATE   ARSENIC
  FROM     TIME DEPTH         TOTAL  TOT NFLT SETTLBLE   N TOTAL  N-TOTAL               CACO3        CL   SO4-TOT    AS,TOT
   TO            FEET          MG/L      MG/L      ML/L      MG/L      MG/L    MG/L P      MG/L      MG/L      MG/L      UG/L
-------- ---- -----        --------  --------  --------  --------  --------  --------  --------  --------  --------  --------
82/03/02 1130  001               65        22         0   0.010K      0.19     0.039         9         3                  10K
82/03/15 1130  001               47         9        0K   0.010K      0.13     0.031         9         3                  10K
82/04/05 1350  001               58        14         0   0.010K      0.23     0.044        10         3                  10K
82/04/20 1350  001               45        10         0   0.010K      0.14     0.037         9         3                  10K

                               1045      1051     31501     31616     39730     70507
  DATE                         IRON      LEAD  TOT COLI  FEC COLI     2,4-D    PHOS-T
  FROM     TIME DEPTH        FE,TOT    PB,TOT  MFIMENDO  MFM-FCBR  WHL SMPL     ORTHO
   TO            FEET          UG/L      UG/L    /100ML    /100ML      UG/L    MG/L P
-------- ---- -----        --------  --------  --------  --------  --------  --------
81/03/24 1130  001              730        5K       500       100
81/03/24 1135  001              690        5K       660       100
81/04/21 1330  001              560        5K        42        11
81/05/18 1320  001              880        5K      1080       450               0.020
81/06/23 1100  001              910        5K       280        30    0.100K     0.020
81/07/21 1045  001              980        5K       240        85               0.023
81/07/21 1050  001              960        5K       120        70               0.022
81/08/25 1045  001             1270         0       160        80               0.026
81/09/29 1130  001             1150         1       620       480               0.089
81/10/19 1440  001              940         0       120        25               0.013
81/10/19 1445  001              910         0        40        35               0.012
81/11/23 1100  001             1200         1       620       115               0.012
81/12/28 1045  001             1040         1       400       135               0.000
82/01/25 1200  001              690         2       260        80               0.014
82/02/15 1050  001              680         1       500       100               0.016
82/03/02 1130  001              570         1       200       100               0.010
82/03/15 1130  001              500         1       100        20               0.012
82/04/05 1350  001              520         1       400        60               0.011
82/04/20 1350  001              450         0       100       20K               0.008
```

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  STATION HEADING                                                                  PDP STORET -- 02-NOV-82                    PAGE   11
                                                                                   ENVIRONMENTAL SERVICES DIVISION
   311LCOG011       LT-BD                                                          EPA REGION 10 -- SEATTLE
  LONG TOM RIVER BELOW FERN RIDGE DAM                                              INVENTORY OF LANE DATA
  44 07 17.0 123 17 54.0  2           ALT=    0FT
  41039 OREGON        PACIFIC NORTHWEST
  WILLAMETTE RIVER                           1309
  21ORMISC  REACH=              DRG AREA=     0 SQ MI
  STREAM/AMBNT

 SUMMARY OF ALL PARAMETERS FROM   / /   TO 99/99/99
                                       #OBS  #OBS                                                             BEGIN      END
   PAR# PARAMETER NAME        UNITS    TOTL  USED       MEAN      STD DEV       MINIMUM      MAXIMUM      PERIOD      PERIOD
 ------ ------------------ ---------   ----  ----  ---------    ---------     ---------    ---------    --------    --------
  00010    WATER     TEMP      CENT      11    11       12.9          5.8           7.0         22.5    81/06/23    82/04/20
  00061   STREAM    FLOW, INST-CFS       11    11     1279.2       1533.2          46.0       4000.0    81/06/23    82/04/20
  00076     TURB TRBIDMTR HACH FTU       11    11       19.6         13.5           5.2         55.0    81/06/23    82/04/20
  00077   TRANSP   SECCHI   INCHES        4     4       22.8         13.6          10.0         42.0    81/06/23    81/12/28
  00095 CNDUCTVY   AT 25C MICROMHO       11    11       53.3         10.3          42.0         70.0    81/06/23    82/04/20
  00300       DO              MG/L       10    10       10.2          1.1           8.4         11.4    81/06/23    82/04/20
  00320      BOD ULT FRST     MG/L       10    10        3.4          1.3           2.0          6.9    81/06/23    82/04/20
  00335      COD LOWLEVEL     MG/L       11    11        9.0          1.9           7.0         14.2    81/06/23    82/04/20
  00400       PH                SU       11    11       6.95         0.21          6.70         7.50    81/06/23    82/04/20
  00410    T ALK    CACO3     MG/L       11    11       16.6          2.9          13.4         22.1    81/06/23    82/04/20
  00500  RESIDUE    TOTAL     MG/L       11    11       66.6         19.1          46.0        121.0    81/06/23    82/04/20
  00530  RESIDUE TOT NFLT     MG/L       11    11       15.8          6.7           6.0         28.0    81/06/23    82/04/20
  00545  RESIDUE SETTLBLE     ML/L       11     0        0.0          0.0           0.0          0.1    81/06/23    82/04/20
  00610 NH3+NH4-  N TOTAL     MG/L       11     1      0.010        0.000         0.010        0.010    81/06/23    82/04/20
  00630  NO2&NO3  N-TOTAL     MG/L       11    11       0.08         0.07          0.01         0.20    81/06/23    82/04/20
  00665 PHOS-TOT            MG/L P       11    11      0.058        0.021         0.029        0.111    81/06/23    82/04/20
  00900 TOT HARD    CACO3     MG/L       11    11       16.4          3.0          13.3         21.9    81/06/23    82/04/20
  00940 CHLORIDE       CL     MG/L       11    11        4.4          1.1           3.1          6.0    81/06/23    82/04/20
  01002  ARSENIC   AS,TOT     UG/L       11     0        0.0          0.0          10.0         10.0    81/06/23    82/04/20
  01045     IRON   FE,TOT     UG/L       11    11      614.5        306.5         190.0       1110.0    81/06/23    82/04/20
  01051     LEAD   PB,TOT     UG/L       11     8        1.0          0.9           0.0          5.0    81/06/23    82/04/20
  31501 TOT COLI MFIMENDO   /100ML LG    11     9      271.1          3.8          20.0       1400.0    81/06/23    82/04/20
  31616 FEC COLI MFM-FCBR   /100ML LG    11    10       72.6          6.2          10.0        960.0    81/06/23    82/04/20
  70507   PHOS-T    ORTHO   MG/L P       11    11      0.012        0.006         0.005        0.027    81/06/23    82/04/20
  STATION HEADING                                                                       PDP STORET -- 02-NOV-82                       PAGE  19
                                                                                        ENVIRONMENTAL SERVICES DIVISION
  3141COG011       LT-8D                                                                EPA REGION 10 -- SEATTLE
 LONG TOM RIVER BELOW FERN RIDGE DAM                                                    SUMMARY OF LANE DATA
 44 07 17.0 123 17 54.0  2              ALT=     0FT
 41039 OREGON          PACIFIC NORTHWEST
 WILLAMETTE RIVER                                1309
 21ORMISC  REACH=                   DRG AREA=     0 SQ MI
 STREAM/AMBNT

                                 10        61        76        77        95       300       320       335       400       410
  DATE                        WATER    STREAM      TURB    TRANSP  CNDUCTVY        DO       BOD       COD        PH     T ALK
  FROM    TIME DEPTH           TEMP     FLOW,  TRBIDMTR    SECCHI    AT 25C            ULT FRST  LOWLEVEL               CACO3
   TO           FEET           CENT  INST-CFS  HACH FTU    INCHES  MICROMHO      MG/L      MG/L      MG/L        SU      MG/L
-------- ---- -----        --------  --------  --------  --------  --------  --------  --------  --------  --------  --------
81/06/23 1000  001             19.0        46       9.1        29        64       9.1       2.6       8.3      7.00        19
81/06/23 1005  001             19.0        46       9.1                  64       9.3       3.1       8.2      7.00        19
81/07/21 0940  001             21.0        49       5.2        42        70       8.6       6.9       8.0      7.10        21
81/08/25 1015  001             22.5        60      12.0                  68       8.4       2.0       9.6      7.50        22
81/12/28 1200  001              7.0      4000      29.0        10        42      11.4       3.3       9.0      6.70        13
81/12/28 1210  001              7.0      4000      28.0        10        45      11.4       3.4       8.6      6.70        13
82/02/16 1130  001              8.5      3100      55.0                  48      11.1       3.6      14.2      7.00        14
82/03/02 1400  001              8.5       900      23.0                  46      10.8       2.6       7.1      6.90        16
82/03/15 1200  001             10.0       220      19.0                  44      11.2       3.5       8.1      6.90        15
82/04/05 1540  001              8.5       920      13.0                  48                          10.8      6.80        15
82/04/20 1330  001             10.5       730      13.0                  45      10.4       2.7       7.0      6.80        15

                                500       530       545       610       630       665       900       940      1002      1045
  DATE                      RESIDUE   RESIDUE   RESIDUE  NH3+NH4-  NO2&NO3  PHOS-TOT  TOT HARD  CHLORIDE   ARSENIC      IRON
  FROM    TIME DEPTH          TOTAL  TOT NFLT  SETTLBLE   N TOTAL  N-TOTAL              CACO3        CL    AS,TOT    FE,TOT
   TO           FEET           MG/L      MG/L      ML/L      MG/L      MG/L    MG/L P      MG/L      MG/L      UG/L      UG/L
-------- ---- -----        --------  --------  --------  --------  --------  --------  --------  --------  --------  --------
81/06/23 1000  001               60        14        0K    0.010K      0.01     0.040        19         6       10K       420
81/06/23 1005  001               55        12        0K    0.010K      0.01     0.040        19         6       10K       410
81/07/21 0940  001               46         6        0K    0.010       0.01     0.029        21         6       10K       190
81/08/25 1015  001               67        16        0K    0.010K      0.02     0.052        22         6       10K       400
81/12/28 1200  001               78        26        0K    0.010K      0.20     0.071        13         3       10K      1040
81/12/28 1210  001               68        23        0K    0.010K      0.19     0.069        13         3       10K      1080
82/02/16 1130  001              121        28        0K    0.010K      0.15     0.111        15         4       10K      1110
82/03/02 1400  001               62        13        0K    0.010K      0.16     0.059        15         4       10K       670
82/03/15 1200  001               66        14        0K    0.010K      0.10     0.068        14         4       10K       610
82/04/05 1540  001               57        14        0K    0.010K      0.01     0.049        14         4       10K       390
82/04/20 1330  001               50         8        0K    0.010K      0.04     0.045        14         4       10K       440

                               1051     31501     31616     70507
  DATE                         LEAD   TOT COLI  FEC COLI   PHOS-T
  FROM    TIME DEPTH         PB,TOT  MFIMENDO  MFM-FCBR     ORTHO
   TO           FEET           UG/L    /100ML    /100ML    MG/L P
-------- ---- -----        --------  --------  --------  --------
81/06/23 1000  001               5K       160       10K     0.010
81/06/23 1005  001               5K       140        30     0.010
81/07/21 0940  001               5K       20K        10     0.008
81/08/25 1015  001                0        20        10     0.014
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STATION:21ORMISC 314LCOG011      LONG TOM RIVER BELOW FERN RIDGE DAM                   PDP STORET -- 02-NOV-82             PAGE  20
-------------------------------------------------------------------------------------- SUMMARY OF LANE DATA


                               1051      31501      31616      70507
  DATE                         LEAD    TOT COLI   FEC COLI     PHOS-T
  FROM    TIME DEPTH          PB,TOT   MFIMENDO   MFM-FCBR     ORTHO
   TO           FEET           UG/L     /100ML     /100ML     MG/L P
-------- ---- -----        --------   --------   --------   --------
81/12/22 1210  001                1       1400        960      0.018
82/02/16 1130  001                3       1000        440      0.027
82/03/02 1400  001                1        500        440      0.008
82/03/15 1200  001                1        100         20      0.006
82/04/05 1540  001                0        200         20      0.005
82/04/20 1330  001                1        100K        20      0.007
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Appendix D

M.E. Harward Report

Report to Lane Council of Governments on
Characterization of Suspended Sediments in
Samples from Fern Ridge Reservoir

Prepared by: M. E. Harward,
Professor of Soil Science

October 6, 1981

Background

A request was received from the Lane Council of Governments (LCG) for some analyses on a service basis. The question posed was identification of suspended sediments and it involved the materials which cause turbidity in the reservoir. Emphasis was on clay minerals present in the samples. Information was also desired on the particle size distribution.

Methods

Preliminary samples of approximately one gallon were received from George Saunders. Determination of the amount of suspended sediments (60-82 mgm/l) indicated that the amount of material would be insufficient for particle size determination. A new set of 5 samples of approximately 4½ gallons each were taken by Mr. Saunders. All data reported are for the second set of samples.

The samples, as received in plastic buckets, were initially frozen to concentrate the solids. After thawing, the bulk of the clear supernatant was siphoned off and discarded. The residual volume containing the solids was transferred to a large beaker and further concentrated by evaporation at 65°C.

The samples were wet sieved through a 300-mesh sieve to remove material greater than 0.05 mm (>50μm). The material retained on the sieve was dried and weighed. One ml of 5% sodium pyrophosphate was added as a dispersing agent to the material passing the sieve. The suspension was agitated with an air-jet stirrer and then made to 1130 ml. After mixing, 25 ml aliquots were taken by pipet at appropriate times for determination of <20μm and <2μm fractions. Percentages of size fractions were calculated on a dry weight basis using the concentration of filterable solids (∿>0.5μm) as determined by LCG.[1]

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[1] Data supplied by Garrett Rosenthal, LCG.

The material remaining after mechanical analysis (<50μm) was used for clay mineral identification. The solids were flocculated in 2 N NaCl and separated by centrifugation. After washing to remove excess salt, the exchange complex was saturated with Mg using 1 N $MgCl_2$ solutions followed by washing. Subsamples were withdrawn and smeared on glass slides to produce oriented clay films for x-ray diffraction analysis. Slides of K-saturated clay were prepared in a similar manner using 1 N KCl. The slides were analyzed using control of ion saturation, relative humidity, solvation with ethylene glycol, and heat treatments to identify the constituents. Details and criteria for identification are available upon request. Samples were analyzed by x-ray diffraction using Cu Kα radiation and a focusing monochromator.

Results

Size Distribution -- Before considering the data, it is necessary to be aware of some of the constraints and methodology problems involved in the measurements. In the normal procedures for mechanical analysis, a 10 gm initial soil sample is used. For these samples, we had to start with whatever was present in the water samples. The weight of solids was less than 1/10 of what is normally used. Consequently, the actual weights of dry material from the aliquots taken by the pipet procedure were low. These were in the range 0.0008 to 0.0045 gms. It is difficult to accurately weigh such small amounts and errors in measurement are expected to be high. Small differences in weight make a large difference in the calculation of percent of a given fraction. Therefore, the data should be used only as indications for orders of magnitude. The second constraint involves the preparation of samples prior to analysis. Ideally, it would be best if nothing was done to change the sample so that the data would reflect insitu conditions. This was not possible and the total volume had to be reduced in order to make the analysis. It is possible that changes induced by the combinations of freezing and subsequent evaporation by heating at 65°C affected the subsequent dispersability of material. The last point to be made is that the 50-20μm (coarse silt) fraction was calculated as a difference assuming initial sediment concentration from the data provided by LCG.

The percent clay size material ranged from 11 to 19% while the percent fine silt were in the range of 10 to 36% (Table 2). The bulk of the material in all samples as analyzed was in the >50 and 50-20μm fractions. The totals of % fine sand plus coarse silt were in the range of 53 to 77%. This result was not anticipated. I had expected apriori to find less silt and more clay. The reason for this unexpected result is not known. Three factors may be involved. It was observed during the study that "fibrous" material (probably organic) appeared to be present. Secondly, flocculation and concentration of samples prior to analyses may have induced some effects which were not overcome by subsequent dispersion procedures.

The third possible factor involves the use of sodium pyrophosphate as a dispersing agent. This reagent was used because it is the "standard" dispersing agent used in particle size analysis of soil samples. It is known to induce dispersion of the crystalline clay minerals (phyllosilicates) because of the presence of the sodium cation. Amorphous materials, however, are more affected by the kind of anion rather than the cation. Phosphate would not be expected to be as effective in dispersion as other anions such as chloride or nitrate for inorganic or organic colloids which behave as anion exchangers. If future work were to involve elucidation of the particle sizes, analysis using a coulter counter and/or dispersion using different salts are suggested.

X-Ray Diffraction -- The clays present in the Fern Ridge Reservoir samples represent a fairly complex suite of minerals (Table 3). The results were similar for all samples. They differed only in sharpness, asymmetry, and intensity of basal (001) diffraction lines.

Long spacing components were indicated by the presence of broad peaks or plateaus in the low angle region of 4 to 5.6° 2θ. The centers of these peaks correspond to about 17-18A. This type of phenomena has generally been attributed to interstratification of 2 or more components. Interstratification of 10A mica and 7A kaolinite would be an example of interstratification with resulting spacings like those observed here. However, interstratification of these 2 components has not been commonly reported and I tend to discount their presence here. The other possibility is the presence of organic compounds in interlayer positions. It was observed that solvation with ethylene glysol resulted in reinforcement of the 17-18A peaks.

Smectite was present as indicated by decrease in the 14A line and reinforcement of the 17A peak as a result of solvation with ethylene glysol.

Vermiculite was indicated in most samples by a residual 14A peak after solvation which shifted toward lower spacings upon K-saturation.

Chloritic intergrades of smectite and/or vermiculite was indicated by resistance in collapse to 10A spacings on K-saturation. Partial collapse was observed on heating to 300° and additional collapse occurred on heating to 550°C. This phenomenon has been attributed to the presence of hydroxy materials, particularly Al, in interlayer positions.

Mica was present as indicated by 10A peaks on the Mg-saturated samples.

Kaolin minerals were present in all samples as indicated by 7.1-7.4A peaks which were unaffected by ion saturation or solvation. This was further confirmed by disappearance of this reflection upon heating at 550°C. The peaks were broad and asymmetric to the low angle side. On the basis of this, plus examination with an electron microscope, this in interpreted as disordered kaolinite. The possibility of dehydrated halloysite was considered, but this could not be confirmed by electron microscopy.

The presence of amorphous components was suggested by a broad "hump" in the region from 18 to 30° 2θ.

Transmission Electron Microscopy -- Samples 1 and 4 were examined with a transmission electron microscope. The photographs presented were chosen to represent the range of materials present.

Material believed to be opaline or diatomaceous was everywhere abundant and predominent. It was necessary to search to find other less common components to illustrate the range of material present. The nature of these fragments are evident in photomicrographs 1c, 1f, 1g, and 4c. The particle in 4c appears more preserved while more highly altered skeletal fragments are seen in 1f and 1g.

Organic material, as individual pieces and probably as coatings, is present. Some of the protruding strands from the clumps is probably organic as well as the particles in upper right of 1h, lower left of 1i, left center of 4b, and lower center of 4g.

Thin, platy material with irregular shape is believed to be smectite. Photo 4a is an example.

Large platy material (4b, 4g) is believed to be mica. Although present, they are not abundant.

Smaller platy particles which tend to be hexagonal are probably kaolinite.

The general matrix and clumps with very diffuse boundaries is indicative of amorphous gel material. In addition to general background, it appears to coat the particles. Bubble-like texture, particularly evident in 4c, results from dehydrating of the gel under the electron beam. The larger particle in the upper center of 4d appears to have a gel-hull.

The general impression from the photomicrographs is a system dominantly of opal or diatomaceous components, organic material, amorphous gels with smectite, and disordered kaolinite as the predominate phyllosilicates.

General Comments

The components present which may be expected to contribute to reservoir turbidity are smectite and amorphous components and organic materials. Smectite characteristically has high cation exchange capacity and a small particle size range. In the presence of dilute solutions and with preponderance of adsorbed monovalent ions, it will form stable suspensions. In the absence of polyvalent anions, amorphous material remains in suspension at low salt concentrations.

Normally, one would not expect mica, vermiculate and chloritic intergrades to remain in suspension for long periods of time. Mica and chloritic intergrades characteristically have low cation exchange capacities and they tend to have larger particle size ranges.

Table 1: Concentration of filterable sediments ($\approx > 0.5\mu m$) in samples from Fern Ridge Reservoir. (Data supplied by Garrett Rosenthal)

Sample No.	mgm/l
1	8
2	10
3	15
4	18
5	16

It should be recognized that the samples analyzed represent complex mixed phases. We know far less about the interactions between particles than we do about "pure" systems. It is quite likely that an amorphous gel coating on a crystalline mineral will impart the properties of the amorphous material to the system. The same question occurs with respect to organic materials. Organic materials were not removed in these samples because we did not want to modify the crystalline components by dissolution treatments. However, throughout the analyses, there were suggestions that organic components were present and these could be important.

Table 2: Size distribution of suspended sediments in samples from Fern Ridge Reservoir

Sample No.	% (Dry Weight Basis)			
	>50μm (fine sand)	50–20μm (coarse silt)*	20–2μm (fine silt)	<2μm (clay)
1	30	44	13	13
2	66	11	10	13
3	27	39	15	19
4**	---------------missing data-----------------			
5	22	31	36	11

*Calculated by difference assuming suspended sediment concentration given in Table 1.

**Part of sample may have been lost due to bucket which split on freezing.

Table 3: Clays identified by x-ray diffraction in samples from Fern Ridge Reservoir

Clay Minerals	Samples 1	2	3	4	5
Long spacing (interstratified?) components	✓	✓	✓	✓	✓
Smectite	✓	✓	✓	✓	✓
Vermiculite	✓	✓	✓	?	?
Chloritic intergrades of smectite and/or vermiculite	✓	✓	✓	✓	✓
Mica	✓	✓	✓	✓	✓
Kaolin	✓	✓	✓	✓	✓
Amorphous	✓	✓	✓	?	✓